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ABSTRACT

The purpose of the National Science Foundation's Course and Curriculum Development (CCD) program is to improve the quality of undergraduate courses and curricula in science, mathematics, engineering, and technology (SME&T). The program also seeks to encourage a greater number of talented faculty to devote creative energy to improving undergraduate learning in the nation's classrooms and laboratories. The projects described in this publication received awards in Fiscal Year 1995 and were selected for their creativity, scientific and educational quality, and potential for utility at multiple institutions and national impact. Projects that received awards were in the following areas: (1) Course and Curriculum Development; (2) Leadership in Laboratory Development; (3) Systemic Changes in the Chemistry Curriculum; (4) Mathematical Sciences and Their Applications throughout the Curriculum; and (5) Science and Humanities: Integrating Undergraduate Education. Projects under Course and Curriculum Development were in the subject areas of biology, chemistry, computer science, engineering, geosciences, interdisciplinary, mathematics, physics and astronomy, and social sciences. (JRH)

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ED 407 249

COURSE & CURRICULUM DEVELOPMENT

1995 AWARDS

COURSE AND CURRICULUM DEVELOPMENT

DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES
DIVISION OF UNDERGRADUATE EDUCATION

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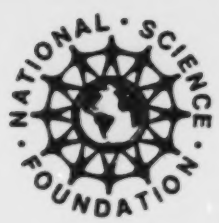

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COURSE & CURRICULUM DEVELOPMENT

1995 AWARDS

COURSE AND CURRICULUM DEVELOPMENT

DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES
DIVISION OF UNDERGRADUATE EDUCATION

NATIONAL SCIENCE FOUNDATION

DIVISION OF UNDERGRADUATE EDUCATION

Undergraduate Course and Curriculum Development Program 1995 Awards

TABLE OF CONTENTS

Foreword iii

Introduction v
Overview v
CCD Program Priorities v

Project Descriptions
Course and Curriculum Development
Biology 1
Chemistry 11
Computer Science 23
Engineering 35
Geosciences 51
Interdisciplinary 55
Mathematics 67
Physics and Astronomy 79
Social Sciences 95
Systemic Initiatives
Systemic Changes in the Chemistry Curriculum - Full Grants 101
Systemic Changes in the Chemistry Curriculum - Planning Grants 105
Mathematical Sciences and Their Applications Throughout the Curriculum 107
Science and Humanities: Integrating Undergraduate Education 111

List of FY 1995 Awards by State and Institution 119

Index of Project Directors 137

Division of Undergraduate Education Personnel for FY 1995 143

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PLEASE CALL (703) 306-1666

Foreword

The National Science Foundation's (NSF) Directorate for Education and Human Resources (EHR) is responsible for providing national leadership and support for enhancing the quality of education in science, mathematics, engineering, and technology at all levels of the educational system. Within EHR, the Division of Undergraduate Education focuses on ensuring that the best possible undergraduate education is provided to meet the Nation's need for high-quality scientists, engineers, mathematicians, and technologists, dedicated and able teachers of pre-college science and mathematics, and scientifically literate citizens.

The *Undergraduate Course and Curriculum Development (CCD) Program* supports the development of courses in all disciplines within the Foundation's mission. Initially, the CCD program has emphasized reform of the crucial lower-division and introductory courses. The enormous interest of the academic community during the first five years of the interdisciplinary program clearly reflects a national need and underscores NSF's important leadership role at the undergraduate level.

The systemic initiative *Mathematical Sciences and Their Applications Throughout the Curriculum* builds on the reform that has taken place through the Calculus Program and other NSF undergraduate programs. Its goal is the development of institutional models with national implications that demonstrate how the mathematical sciences can be integrated into other disciplines and how instruction in the mathematical sciences can be improved through incorporation of other disciplinary perspectives.

Another initiative, *Systemic Changes in the Undergraduate Chemistry Curriculum*, is attempting to enhance the learning and appreciation of science through significant changes in chemistry instruction. NSF is supporting projects that are designed to make fundamental changes in the role of chemistry within the institution, including better integration with curricula in related disciplines such as biology, physics, geology, materials science, engineering, computer science, and mathematics.

The projects described in this book received awards in FY 1995, and were selected for their creativity, scientific and educational quality, and potential for utility at multiple institutions and national impact. We are proud of these projects and hope that they will be of interest to science, mathematics, and engineering faculty at all U.S. colleges and universities. Building on the courses and curricula developed in these projects, institutions can work toward achieving comprehensive, institution-wide reform of undergraduate education.

Luther S. Williams

Luther Williams
Assistant Director
Directorate for Education and Human Resources

NATIONAL SCIENCE FOUNDATION
UNDERGRADUATE COURSE AND CURRICULUM DEVELOPMENT
INTRODUCTION

Overview

The purpose of the National Science Foundation's Course and Curriculum Development (CCD) program is to improve the quality of undergraduate courses and curricula in science, mathematics, engineering, and technology (SMET). The program also seeks to encourage a greater number of talented faculty to devote creative energy to improving learning by undergraduates in the Nation's classrooms and laboratories. In FY 1995, the CCD program granted awards to 126 new projects from 39 states and the District of Columbia. Support was based on the recommendations of notably qualified panelists. Projects receiving awards are those that address CCD objectives in the areas of:

- Course and Curriculum Development—*98 Awards*
- Leadership in Laboratory Development— *8 Awards*
- Systemic Changes in the Chemistry Curriculum—*7 Awards*
- Mathematical Sciences and Their Applications Throughout the Curriculum—*3 Awards*
- Science and Humanities: Integrating Undergraduate Education—*10 Awards*

Total award amounts include funding from the Directorate for Education and Human Resources, other NSF research directorates, and other agencies. Common themes in these awards are the creation of modules and the use of new technology to develop innovative pedagogical techniques, and the design of stimulating curricula intended to attract, encourage, and retain groups currently underrepresented in SMET enrollment. Awarded projects are expected to produce course and curriculum materials that will be of broad national interest and intended for wide dissemination. While the majority of program funds support proposals for introductory-level courses, curricula and laboratories, the CCD program also supports proposals intended to benefit upper-level students. This summary highlights representative examples of the newly awarded projects, while the attached awards list includes previous CCD projects that received additional funding in FY 1995.

CCD Program Priorities

The current priorities of the CCD program are two-fold: 1) to promote the development of multidisciplinary and interdisciplinary courses that will better prepare students for the science- and technology-based environment of the future; and 2) to encourage SMET faculty to take leadership roles in developing educational experiences

that enhance the competence of prospective teachers and encourage students to pursue teaching careers.

Course and Curriculum Development Projects

Several CCD awards in FY 95 were made to support projects that promote the development of inter- or multidisciplinary courses. As examples of such courses, Yale University (CT) is designing graphics software and instructional materials for three fractal geometry courses, including an introductory pre-calculus course emphasizing connections to art, economics, music, and philosophy. The University of California-Los Angeles (CA) is developing an innovative laboratory format that explores the interrelationships of atmospheric science, biology, chemistry, mathematics, and physics. Hampshire College (MA) is conducting a conference to bring together faculty from a variety of disciplines and diverse institutions to document successful approaches in the teaching of science in which students are active participants. City University of New York (CUNY)-Manhattan (NY) is adding chemistry, computer science, and physics to its mathematics courses to emphasize the interrelationship of scientific disciplines. Carnegie Mellon University (PA) is integrating environmental issues into introductory engineering courses to provide students with exposure to environmental concerns and problem-solving methods for their respective engineering disciplines. Brown University (RI) is developing teaching and research tools on human behavior, including communication, speech and gesture, writing and language acquisition.

A number of the 1995 awards propose to develop educational experiences that enhance the competence of prospective teachers in science and mathematics and encourage students to pursue careers in teaching. The University of Florida (FL) is offering a course for future elementary teachers focusing on current engineering topics, presented in a manner that can later be used in the classroom. In its *Science as Constructive Inquiry* project, CUNY-Brooklyn (NY) is developing a science preparation sequence for urban pre-service elementary teachers designed and piloted by faculty from biology, chemistry, geology, and physics. A project led by Dickinson College (PA) is offering three introductory physics curricula that promote scientific literacy and motivate students through the mastery of concepts, investigative skills, and modeling techniques; workshops for high school and college-level instructors, public talks, site visits and publications are included for the dissemination of project materials.

The creation of instructional modules is included in a number of the current CCD projects. The College of Du Page (IL) is developing laboratory modules that reflect the latest innovations and theoretical applications from practitioners of atmospheric science and meteorology. An introductory program at Columbia University (NY) will examine quantitatively human nature from biological, social, and information processing perspectives. This modular program provides the infrastructure for a core curriculum in science that emphasizes student participation in data collection and analysis. The American Association of Geographers (DC) is infusing curricula with topics in global change that include faculty and pedagogical experts in the development of activity-based modules on global change, with particular reference to human motivation and responses.

Iowa State University (IA) is collaborating with 15 community colleges, three public universities and four private colleges in using instrumentation-oriented modular instructional resources to emphasize conceptual thinking, interactive multimedia and exploratory laboratory experiments. Similarly, the New Jersey Institute of Technology (NJ) is leading a consortium of 19 community colleges in developing model and training curricula for manufacturing systems.

Several institutions propose the use of technology to enhance the learning experience for their undergraduate students. Four university units at the University of Georgia (GA) are collaborating on the implementation of a Geographic Information System and an interactive multimedia program to guide students in long-term ecological studies, including the testing of formal hypotheses based on collected field data. The University of Utah (UT) leads a group using computer-based laboratories to illuminate scientific principles and provide computational solutions to real-world problems in science and engineering. Massachusetts Institute of Technology (MA) is designing educational software for undergraduates enrolled in cellular biophysics courses. A group led by Duke University (NC) is developing a comprehensive, introductory computer science course, simulating the levels of processing in an idealized machine. Washington University (MO) is designing computer-graphics color animation to illustrate the geological processes contributing to the propagation of seismic waves, earthquakes, and plate tectonics. A consortium based at Virginia Polytechnic Institute and State University (VA) is developing a novel laboratory approach to instruct engineers in introductory statistics, emphasizing problem-solving, conceptual understanding, and writing skills.

South Seattle Community College (WA) is working in cooperation with Boeing Company, Eldec Corporation, Clover Park Technical College and 12 other organizations to develop a process for determining specific workplace standards for manufacturing education and training. San Jose State (CA) is creating an education and training center for mechatronic systems that involves the development of new courses and laboratories in mechatronic engineering, as well as revitalizing the extant curriculum. Sonoma State University (CA) is developing a networked simulation of the international financial system that allows groups of students to interact with each other. Because outcomes depend on their combined decisions, it simulates the dynamics of real-world economic systems.

Several awarded projects are oriented towards specific populations of students. In a project that targets large, general education courses for non-science majors, Radford University (VA) is using computer-aided learning modules to teach fundamental concepts of geology. The University of North Dakota (ND) is addressing the needs and expectations of paraprofessional engineering students by offering an enhanced curriculum for adult learners based in industry. The Biological Sciences Curriculum Study (CO) is providing an integrated and coherent approach to biological literacy for students enrolled in community colleges. By incorporating the evaluations of students in this project's design, the instructional materials will also be of interest to future K-12 teachers. Central Texas College (TX) is providing challenging, entry-level community college courses to improve the success of groups underrepresented in SMET, including African Americans, Hispanics, and women. The project also includes a workshop for science teachers from area high

schools. Rutgers University (NJ) is also encouraging its large minority student population through outreach efforts in its introductory physics laboratory course. The University of Southwestern Louisiana (LA) is targeting the emerging discipline of computer information science with an ambitious project that provides detailed curriculum guidelines, laboratory materials, original teaching and learning paradigms, and methodology for dealing with complex information systems.

Leadership in Laboratory Development (LLD)

Leadership in Laboratory Development (LLD) projects are those that fundamentally reform and improve experiences in the laboratory, and that have the potential to serve as models nationally. Awardees include the University of Massachusetts-Amherst (MA), which is leading the development of a computer laboratory for the teaching of fundamental molecular genetics. *MOLGENT* exploits advances in technology to provide multimedia instruction more thoroughly and effectively than traditional lectures or textbooks. The University of Louisville (KY) is developing a laboratory course in microfabrication, providing an introduction of this versatile and powerful technology to a broad student audience. The University of North Carolina (NC) received an award to lead in the creation of a library of interactive, experimental workbooks in mathematics, to be provided free of charge over the Internet.

Systemic Changes in the Chemistry Curriculum

Systemic Changes in the Chemistry Curriculum is one of two initiatives that encourage institutions to reexamine the roles of disciplinary departments within the instructional program as a whole. Awards in FY 95 include the Modular Chemistry Consortium led by the University of California-Berkeley (CA). In collaboration with 17 other two- and four-year institutions and universities, they are developing new curricula and methods intended to enhance the learning of chemistry and retention of this knowledge for all college graduates. The program uses modules to present chemistry in the context of real-world problems; the scientific skills learned by students can be applied to inform decisions throughout their lives. In collaboration with this project, the *ChemLinks Coalition* centered at Beloit College (WI) is developing instructional materials and course modules using active, cooperative methods of learning chemistry, including a model for students preparing for careers in teaching. Collaborators on the project include liberal arts colleges (Beloit, Carleton, Colorado, Grinnell, Hope, Kalamazoo, Knox, Lawrence, Macalester, Rhodes, Spelman, St. Olaf, Wooster), two-year colleges involved in the Advanced Technology Environmental Education Center, as well as research universities (Chicago, Washington-St. Louis). Heading a consortium that includes 10 four-year and community colleges and the Universities of Pennsylvania, Pittsburgh, and Rochester, the *Workshop Chemistry* project based at CUNY City College (NY) will use small group, student-led workshops to complement chemistry lecture and laboratory components, with an emphasis on skills in problem-solving, communication and teamwork. In the *New Traditions* project, the University of Wisconsin-Madison (WI) is also leading a consortium of public and private institutions to establish new learning

communities, curricula, materials, and methods for student learning of chemistry. All of the projects include specific components emphasizing pre-service teacher training and the education of technology specialists.

Mathematical Sciences and Their Applications Throughout the Curriculum

Mathematical Sciences and Their Applications Throughout the Curriculum supports projects that promote comprehensive institutional changes by integrating the mathematical sciences into other disciplines, and that improve instruction in the mathematical sciences by incorporating perspectives from other disciplines. Integration of mathematics with courses in architecture, art, biology, computer science, geology, economics, engineering, literature, medicine, music, philosophy, physics, and social science is the goal of a consortium led by Dartmouth College (NH), which includes the cooperation and participation of approximately 40 diverse two- and four-year colleges and universities. Software, on-line materials, and videotapes are among the resource materials to be developed, along with a series of intensive summer workshops. Rensselaer Polytechnic Institute (NY), in collaboration with Central State University, the University of Delaware, Hudson Valley Community College, the University of Maryland, Siena College, and Virginia Polytechnic Institute is focusing on linkages between mathematics and disciplines in science and engineering. The University of Pennsylvania (PA) leads a consortium including the Community College of Philadelphia, Polytechnic University, Villanova University, the Society of Industrial and Applied Mathematics, and public schools. This project promotes faculty responsibility across disciplines for effective SMET education, and integrates research and realistic applications into the undergraduate experience.

Science and Humanities: Integrating Undergraduate Education

The *Science and Humanities* program, jointly supported by NSF and the National Endowment for the Humanities, promotes the development of courses and curricula that link meaningfully the study of science and the humanities. The 1995 award recipients include Mt. Holyoke (MA) for its *Mathematics Across the Curriculum* project, which introduces students to the application of mathematical ideas and reasoning to introductory humanities courses in an engaging and non-threatening context. Southwest Texas State University (TX) is providing a summer institute for college faculty, transcending traditional disciplinary boundaries and emphasizing an interdisciplinary content in its multi-faceted study of the physical, historical, environmental, and cultural aspects of the Southwest United States.

BIOLOGY

The BioQUEST Curriculum and Learning Tools Development Project

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DUE-9354813
FY 1994 $ 235,221
FY 1995 $ 161,719
Biology

This project provides the essential philosophies, tools, resources, support, and sharing networks that enable postsecondary biology faculty to examine, critique, and change their biology curricula. A variety of mechanisms is being employed, including the publication of a book and the hosting of three learning tools development workshops. The book is a multi-authored, collaborative work based on the BioQUEST 3Ps philosophy, with specific examples highlighting use of materials in the BioQUEST Library, use of the 3Ps in wet laboratories and field work and situations where computers are not necessary, and discussions of the specific issues related to development and implementation of open-ended, research experiences for students. The project also supports curricular reform and learning tools development through three summer workshops in three major areas of biology. Materials and information are being disseminated through the book, *BioQUEST Notes*, the BioQUEST Library, the Introducing BioQUEST Hypercard stacks, and at conference presentations and workshops. Materials are being field tested as part of the three-stage review process for publication in the BioQUEST Library and will be distributed through other publications such as journal articles and laboratory books, electronic networks, and the monthly consortium status reports.

Computer-Integrated Introductory Biology Lab

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DUE-9455447
FY 1995 $ 415,601
Biology

The Computer-Integrated Introductory Biology Lab (CIBL) project is a three-year development effort to combine an innovative format for undergraduate biology laboratories with a thematic, cross-curricular approach to content instruction that integrates biology, physics, chemistry, atmospheric sciences, and mathematics. The CIBL laboratory supports and extends hands-on "wet" laboratory experiences using computer-based multimedia (interactive video, graphic, sound, and simulations). This will transform the large Introductory Biology Laboratory class at UCLA from a "barrier course" to a "facilitator course" as part of a larger effort at UCLA to recruit and retain student enrollment in science, especially within minority groups whose members are underrepresented in scientific careers. The project will develop and publish eight laboratory modules. Students preparing to be science teachers will be involved with the design, testing and evaluation of the materials.

A New Model for Introductory Biology at Two-Year and Community Colleges

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DUE-9455725
FY 1995 $ 650,000
FY 1996 $ 435,000
FY 1997 $ 435,000
Biology

In recognition of the importance of introductory biology courses at two-year and community colleges to the development of scientific literacy among college-educated individuals, Biological Sciences Curriculum Study is conceptualizing, writing, testing, and evaluating a set of innovative curriculum materials for biology students at the college level. Collaborating in the 36-month project are 15 partners. The completed program will offer an integrated and coherent approach to helping students achieve three major goals of biological literacy: (1) to understand the basic unifying principles of biology; (2) to develop the fundamental skills of critical thinking and scientific reasoning; and (3) to recognize the applications of science, especially relationships among science, technology, and society. The materials being developed are of use to future teachers of science at the elementary and secondary levels. Strategies are incorporated that encourage students to reflect on the overall design of the program including strategies to help them learn various teaching techniques and for assessment. The products of the project include student materials (readings, activities, and laboratory exercises) that support both semester- and year-long introductory biology courses and emphasize hands-on, open-ended inquiry, collaborative learning, and the relationships among science, technology, and society; an instructor's guide that provides faculty with extensive background reading and specific implementation support; and a model for a faculty development workshop that is being designed and tested by the partner faculty and supported after the end of the project by revenues realized from sales of the materials.

Computer Applications to Enhance Inquiry-Oriented Laboratory Instruction in Biology at a Two-Year College

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DUE-9254228
FY 1993 $ 132,180
FY 1994 $ 82,125
FY 1995 $ 83,177
Biology

This project addresses the general problem of scientific and technical literacy and specifically the enhancement of inquiry-oriented laboratory instruction in biology. Project goals are to increase scientific literacy, reasoning skills, and the number of students succeeding in introductory biology courses. To achieve these goals, the project is developing, evaluating, and integrating into the curriculum a set of computer applications designed to reinforce biology concepts introduced in exploratory laboratory activities and integrate reasoning skills for use in new contexts. These efforts focus on an introductory biology course at a 2-year college that

serves a non-traditional undergraduate population including high numbers of women, Hispanics, Native Americans, and older students. Mesa Community College serves a large transfer and reserve transfer population associated with a nearby comprehensive university. As a result of this instructional intervention, the college's classes will have improved achievement in biology, scientific reasoning skills, attitudes toward science, retention of underrepresented student populations, computer literacy, and instructor efficiency and effectiveness. The results will document the efficacy of a refinement to inquiry-oriented laboratory instruction and provide a model for the use of technology in education.

Laboratory Exercises in Plant Biochemistry

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DUE-9550791
FY 1995 $ 48,208
Biology (LLD)

This project is developing a series of experiments on plant acids and pigments designed to implement a new approach to engaging students in science. The target audience of these exercises is non-major biochemistry students. The experiments are designed to focus on the development of student expertise in the use of research tools, expose all students to the process of scientific research, and provide a framework for cooperative learning opportunities. Coordinated experiments are being developed which reward students with a sense of progressive mastery of earlier concepts and tools, and foster a holistic view of science. The goal of this tool-based approach is to empower students to generate and answer their own questions about the world around them and lead them into independent investigations. Plant acids are used to provide a pedagogical vehicle for learning about pH and biological buffering, while providing a relevant bridge to familiar commercial products. Plant pigments, specifically anthocyanins, chlorophylls and carotenoids, are used to provide an interesting and colorful approach to an understanding of biochemical phenomena. The developed exercises are being field tested at the PI's institution and disseminated without cost to interested undergraduates and educators via the Internet. The methods and exercises developed as part of this project will be utilized in the development of an advanced science content course for pre-service teachers in collaboration with faculty from the University of Nebraska Teachers College.

An Enhanced Bioscience Education Program for the Introductory Years of the Biology Major and for Interested Preteachers

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DUE-9253994
FY 1993 $ 269,266
FY 1994 $ 7,728
FY 1995 $ 48,794
Biology

The Enhanced Bioscience Education program greatly increases the effectiveness of undergraduate education in the biological sciences. The new integrated curriculum presents science as it is practiced as a problem-solving, investigative activity. The curriculum is designed

for up to 100 bioscience and teacher preparation majors. It is organized around topic areas and extends over five quarters of instruction: (1) Biological Investigation is the heart of the curriculum and consists of a series of laboratory modules covering the important concepts of modern biology, leading students toward design of their own experiments. There is a strong emphasis on use of computers for collecting data and for data analysis and interpretation. (2) Principals of Bioscience includes the content areas now covered in freshman biology, cell physiology, microbiology and genetics presented as a single, coherent sequence and completely integrated with Biological Investigation laboratories. (3) Physical Sciences and Mathematics covers the topics of freshman and sophomore chemistry, mathematics and physics, with the appropriate information and skills introduced in the order needed. An Undergraduate Research Program includes freshman and sophomore independent research projects, preparation for more advanced projects, and the establishment of the Drexel Journal of Undergraduate Research as a vehicle for dissemination of student research. Special attention is paid to problems of student support and retention. Specific plans are included for evaluation and effective dissemination of the outcomes of the project.

Cellular Biophysics Software

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DUE-9455337
FY 1995 $ 150,000
Biology

The purpose of this project is to make educational software and methodologies for its use in teaching cellular biophysics widely available. Software has been used for 10 years to teach cellular biophysics to juniors majoring in engineering and science at the Massachusetts Institute of Technology (MIT). The software is used in lecture demonstrations, special recitation classes held in electronic classrooms, as a basis of homework assignments, and for more intensive research projects defined by students. Use of the software has greatly enhanced students' interest in and comprehension of topics in cellular biophysics. All the software has been developed by student programmers and is currently available only on UNIX workstations at MIT. The software is written in C and XWindows. The goal of the project is to support undergraduate and graduate students converting this software to run under a vendor distributed computation and visualization software package (MATLAB) which is available on all the common computer platforms, including Macintoshes, PCs running Microsoft Windows, and UNIX workstations running XWindows. The conversion also allows students and instructors to more readily customize the software for their own use, and will greatly facilitate software maintenance for faculty. The plan is to publish a software textbook that will be distributed with floppy disks of the software. The software and software textbook will be companions to a new textbook on cellular biophysics that was scheduled for publication in Fall 1995. The combination should provide a new set of educational materials for teaching cellular biophysics to students in engineering and science. The approach is to provide rigorous, in-depth mathematical treatments as well as the empirical basis of important biological, chemical, and physical principles of cell biophysics. The software, together with the software text, allows students and faculty to explore these principles in new ways. The educational effectiveness of the software will be assessed by an independent evaluator.

Career Direction Through Integrated Introductory Biology-Chemistry Laboratory and Research

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DUE-9455288
FY 1995 $ 162,000
Biology

This project is a three-step sequential undergraduate biology-chemistry experience to retain science majors and to inspire them to enter research careers. Step I occurs in a student's first year with an integration of the second semester laboratories of the majors' introductory biology and chemistry courses. Lectures remain separate. To follow the student experience of the integrated laboratories and to retain and build upon student interest in science research, Step II is a required career seminar course in the Spring of the sophomore year. Seminar speakers from academia, medicine, and industry serve as hosts for students participating in Step III, a Summer research internship between the second and third years of college. Steps II and III function together in the sophomore year to provide a practical application of the integrated first year laboratories and to reinforce research career goals. Two laboratory sections concurrently participate in Step I to pursue a number of nontraditional, investigative laboratory modules which integrate concepts from cell biology, molecular genetics, and general chemistry. Seven hours per week is divided into formal laboratory investigation, discussion, and comeback time. Over a 12-week period, four modules are presented. These integrated, modular laboratories examine (1) Vitamin C Metabolism, (2) Reaction Dynamics of Enzymes, (3) Sources of Energy for Life, and (4) Manipulation of Macromolecules. During the final week of each module, students analyze data, draw conclusions and, in selected modules, design their own original investigations based on previous experimentation. Mathematics tutorials are available. This integrated, biological-chemical modular format directly relates to and prepares science majors for modern research-oriented upper division courses and parallels a realistic career research experience. One section of the integrated biology-chemistry laboratories is comprised entirely of women, for comparison with the other two of mixed gender, and with the traditional separate biology and chemistry laboratories for the other students.

Conferences on Communicating and Assessing Innovative Strategies for Life Sciences Teaching to Undergraduates

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DUE-9455616
FY 1995 $ 31,236
FY 1996 $ 43,810
FY 1997 $ 35,946
Biology

This project supports the Coalition for Education in the Life Sciences (CELS), a network of life science professional organizations, to convene three conferences on undergraduate life science education. The conferences to be held in 1995, 1996, and 1997 are the fourth, fifth, and

sixth in a series. The conferences emphasize assessment of educational programs, development of a life sciences electronic clearinghouse, dissemination of information about exemplary programs, and ways for improving faculty and graduate assistant teaching and course design. The first conference was held in June, 1995, at The University of Wisconsin, Madison; the second will be held in 1996 at the University of Nevada, Las Vegas; and the third will meet in Washington, DC. The conferences are limited to 175 participants to promote interaction, and CELS encourages faculty and administrators from the same institution to attend as teams. The format includes plenary sessions on broad topics like assessment, smaller break-out discussions and hands-on workshops, materials presentations and group discussions, and demonstrations that show effective teaching. The outcome will be teaching materials and conference proceedings, which will be disseminated through all the professional societies supporting CELS and a self-sustaining CELS network for ongoing work in this important area of undergraduate life sciences education.

Coupling Mathematics and Life Science Courses: Development of Integrated Math and Science Curricula for Undergraduate and Middle School Students

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DUE-9455601
FY 1995 $ 51,293
Biology

The goal of this project is to create a unified curriculum which develops the students' quantitative approaches to problems in the life sciences. This project couples an introductory statistics course with a general biology laboratory course at the University and develops teaching units for the middle school level. The key to the long-term benefits and widespread significance of this project is that a teaching circle is being formed which is interdisciplinary and includes middle school teachers. This collaborative team is united by commitment to teach science and mathematics from an integrated, project-based, problem-solving approach. It brings together education and subject matter experts. The summer of 1995 was spent developing flexible teaching modules which can be used to couple general biology and statistics or that can be used with either course independently at the undergraduate level, and in the development of teaching units for middle school concept/process science and mathematics. The following summer the faculty will analyze their experience and revise the materials based on assessment tools that evaluate student attitudes, interest, and skills. Locally, this project is revising the manner in which biology and mathematics are taught at the University of Portland and Portsmouth Middle School. It will impact future teachers through student-teacher placements and through the University's teaching methods courses in the School of Education. Coupling mathematics and science will lower the life science students' math anxiety level and help the student become comfortable with looking at biological phenomena from a quantitative perspective. This approach is especially significant because it will encourage students to stay in science, and the middle school has a high percentage of minority students.

Biological Literacy Through Classroom Community

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DUE-9156087
FY 1992 $ 77,702
FY 1995 $ 19,670
Biology

Biology teaching should incorporate the process of scientific inquiry, not just the information resulting from it. Only by involving students directly in scientific experimentation and intellectual debate can they be expected to develop the fundamental understanding of biology required for biological literacy. Engaging students in this process demands a classroom that motivates learning, teaches analytical skills as well as information, and captures the spirit of curiosity and questioning. To meet these demands for the broadest spectrum of students this project addresses three objectives. First, simple, low-cost experimental exercises are being designed that illustrate fundamental biological principles and can be conducted in an introductory course without a laboratory. Second, a set of exercises in scientific study skills is being constructed to address the difficulty, shared by many college students, of learning scientific material. The innovative aspect of this approach to study skills is that the students are in a forum that is tightly coupled with the biology instruction, which provides for exchange between the biology instructor and the study skills instructor. Finally, drawing on cooperative learning approaches that are highly effective in other fields, exercises are being developed that can be used to involve all members of small or large classes in active thinking and learning. The product of this project will be a published manual that explores the philosophy of building community in the classroom and describes the exercises in experimentation, study skills, and cooperative learning that can be incorporated into introductory-level biology curricula.

Computer Graphics in Introductory Biochemistry

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DUE-9455324
FY 1995 $ 100,000
Biology

The purpose of this project is to introduce interactive tutorials using three-dimensional computer graphics to visualize macromolecular structure and function into introductory biochemistry. Specific goals include the development of 14 computer graphics tutorials to be used in the introductory auto tutorial biochemistry course, the publishing of these tutorials, and the holding of workshops for training teaching faculty at other universities to use these tutorials. One difficulty associated with developing such an interactive curriculum for introductory biochemistry is the large class size. For this reason, this auto tutorial biochemistry course provides an excellent forum for curriculum development, because it has already successfully adopted a highly personal and interactive format. This computer graphics based curriculum should have a large impact on undergraduate education, because many undergraduates take introductory biochemistry courses each year, and very few (if any) such courses currently have interactive, three-dimensional, graphics content. This curriculum should be effective, both for

attracting more students to continue in biological sciences and for preparing the scientific and biomedical community of tomorrow so that they may assimilate and effectively apply structural information about proteins and other biological molecules.

Interactive Multimedia Simulations of Experimental Biotechnology Laboratories for Introductory Biology Students

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DUE-9455425
FY 1995 $ 108,464
Biology

Over 600 students (mainly non-science majors) take Introductory Biology at the University of Wisconsin-River Falls each year. Many of these students tend to equate success in college with the ability to memorize facts, and need more exposure to critical thinking skills used by scientific investigators. Research on gender issues in science education indicates that computer simulation is a particularly effective way to interest more women in pursuing scientific careers. The project is developing highly interactive experimental simulations based on existing upper-division laboratories in the biotechnology curriculum (Virology, Molecular Biology, and Animal Cell Culture). These simulations are used by Introductory Biology students to generate and test their own hypotheses while working in small collaborative groups. Students manipulate objects on the computer screen much as they would in reality. For example, they can "spin" the dial of a micro pipette or operate the control panel of a spectrophotometer, DNA thermal cycler, or electron microscope. Digitized video images of students using actual equipment are incorporated into the simulations to make them more realistic. Undergraduate education majors enrolled in a teaching methods class are involved in the evaluation of the simulations, which gives them first-hand experience in evaluating the uses of technology in the classroom. The editorial staff of BioQUEST is providing assistance in the dissemination of the simulations.

Molecular Genetics Concepts: An Intelligent Tutor

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DUE-9551531
FY 1995 $ 273,459
Biology (LLD)

This project is developing a computer laboratory for tutoring undergraduate students in fundamental concepts of molecular genetics. The topics covered include DNA structure and replication; RNA transcription, translation, and splicing; genetic recombination, repair, and transposition; genetic engineering and recombinant DNA technology; and modern genomic analysis and societal implications. The major challenges in teaching these fundamental genetic concepts to undergraduates are (1) transmitting the visual imagery of dynamic molecular processes; (2) providing a solid intellectual framework to explore interrelationships between

genetic processes; and (3) at more advanced levels, conveying the experimental basis for evolution of genetic principles. The project exploits recent advances in computer hardware (increased memory size and data storage) and software (intelligent tutoring systems) to develop a multimedia tutorial package which conveys the visual imagery, conceptual relationships, and experimental basis of molecular genetics in a deeper and more effective manner than currently possible through lectures or textbooks. The electronic tutor, named "MOLGENT", is being tested during its developmental phase in a variety of undergraduate classes, including introductory biology, microbiology, and molecular and cellular biology courses, and an innovative senior-level course entitled "Concepts in Molecular Genetics." The effectiveness of tutorials is being monitored and improved through student discussion groups. Once developed, the prototype software will be promoted via demonstrations at the educational section of meetings of biological societies (e.g., American Society for Microbiology, Genetics Society of America, and American Society for Biochemistry and Molecular Biology) and distributed broadly via publishers.

Development of a Materials-Oriented General Chemistry Course

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DUE-9254107
FY 1993 $ 699,999
FY 1995 $ 50,000
Chemistry

A materials-oriented approach to chemistry is being developed through the preparation of course materials entitled "Teaching General Chemistry: A Materials Science Companion", by an ad hoc committee of two dozen leading chemistry researchers and teachers. Consisting of text, problem sets, model kits, software, videotapes, demonstration and laboratory experiments, the "Companion" was published by the American Chemical Society in 1993. The "Companion" demonstrates how virtually every topic typically covered in introductory chemistry courses can be illustrated with solids such as semiconductors, metals, superconductors, polymers, and ceramics. The project focuses both on innovation—the completion of material for the "Companion"—and on change—the implementation of a national strategy for assimilating materials chemistry into introductory chemistry courses. Strategies for effecting change include national testing of the "Companion" at over two dozen volunteering college test sites (more than 15,000 students); development of modules based on the "Companion" and their use in workshops for college and pre-college teachers; and critical evaluation of the instructional materials by teachers and students through direct feedback and measures of student interest and performance. The "Companion" and supporting activities will revitalize general chemistry courses, enhance the scientific literacy of students and teachers, and increase the number and diversity of high-quality students electing to pursue careers as chemists, chemistry teachers, scientists and engineers. Some of the materials in the "Companion" can also be used in other introductory science and engineering courses. The steps involved in organizing and implementing this project are being summarized and disseminated.

Development of Computer Graphic Visualization Aids for the Undergraduate Chemistry Curriculum

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DUE-9354453
FY 1994 $ 100,000
FY 1995 $ 100,000
Chemistry

This project is developing high-end, workstation-quality computer graphics to aid in the visualization of concepts taught throughout an undergraduate chemistry curriculum. The goal of the work is to focus on visual presentations and real-time visual manipulations of a variety of concepts that are included in the current chemistry curriculum. Specific projects include three-dimensional animation sequences of atomic and molecular orbitals, three-dimensional views of polymer structure and stereochemistry, videos that introduce basic stereochemical concepts in organic chemistry, and animated sequences of crystal structures and Miller index planes. Additional projects include other basic organic transformations, periodic trends, and

hybridization. The specific goals of this project are to develop materials that can be used in courses throughout the United States and can be readily distributed on computer disks, laser disks, and videotapes, so that the efforts of this project can have a broad impact on the national undergraduate and high school chemistry curriculum.

Introduction of Modern Instrumentation in the First Two Years of Chemistry: The Iowa Chemistry Curriculum Network (IACCN)

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DUE-9455646
FY 1995 $ 260,621
Chemistry

This project is researching, developing, and incorporating three modular instructional resources on modern instrumentation into the first two years of college chemistry. The modules contain instrumentation-oriented components dealing with current real-world topics, group projects, updated teaching methods, student learning assessments, emphasis on conceptual thinking, interactive multimedia, and exploratory laboratory experiments. Development of interactive, multimedia computer programs that simulate the operations of the FT-IR, and FT-NMR spectrometers, from sample handling to data acquisition and workup, is being developed in collaboration with Engineering Animation, Inc. A UV-VIS multimedia simulation has already been developed at the University of California at San Diego. A consortium of Iowa's 15 community colleges, three public universities, and four private colleges are collaborating on all aspects of the project through long-distance video conferences on Iowa's fiber-optics communication network and at annual summer workshops. This project is enabling students and faculty in the entire state of Iowa to have facile access to modern instrumentation (UV-VIS, FT-IR and FT- NMR) via computer simulations. Iowa State University is serving as a clearinghouse for running actual chemical samples submitted by students of the participating institutions. The samples are being run on instruments at Iowa State University, and the spectra are being made available to the students and faculty from the community colleges and private colleges over the Internet (via anon ftp, the World Wide Web, or by e-mail) as digital files or graphic images. This project is providing new curriculum enhancements and developments to four-year institutions and all community colleges in the state of Iowa.

Building Conceptual Frameworks with Synchronized Multiple Visualizations

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DUE-9455747
FY 1995 $ 91,593
FY 1996 $ 62,284
Chemistry

A common dilemma of first-year college chemistry is that the needs of diverse student populations are not being met by the traditional instructor-focused classroom. At College of

DuPage, Oakland Community College, and Oakland University, this diversity includes ethnicity, age distribution, aptitude, science background, and learning styles. In this project, classroom time is being used to help students develop conceptual understandings that incorporate the ability to view phenomena from multiple perspectives. Classroom activities stress active learning and scientific exploration. Topics and methods are used that reflect contemporary science integrated with the personal experiences and interests of students. Interactive-multimedia materials, showing synchronized multiple representations of chemical species and phenomena, are being developed and used in classrooms and by groups of students. A sense of ownership of new materials and commitment to their use is being developed by involving faculty, from all institutions, in their selection, design, development and evaluation. Student versions encourage group learning and exploration. Training workshops are aimed at assisting faculty in implementing the multimedia materials in manners that promote more active learning environments. Evaluations assess: (1) changes in classroom pedagogy, (2) achievement gains of students, and (3) changes in students' attitudes toward science. Project products will be nine multimedia modules, student versions of each module, training workshops and their support materials, assessment materials and research analyses of the effectiveness of all products.

Biologically-Relevant Chemistry in the Freshman Laboratory

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DUE-9455418
FY 1995 $ 190,000
Chemistry

In this project, which is an innovative approach to teaching the freshman chemistry laboratory, students are exposed to a variety of chemical principles in the context of biologically-relevant chemistry. Large numbers of students taking freshman chemistry (upwards of 60%) are pursuing careers in the biological sciences and/or medicine. These students are being shown the relevance of chemistry in understanding biological systems by engaging them in authentic scientific inquiry. The program is module-based, where each module focuses on a specific question that the students must answer about a biologically-relevant problem. Each laboratory module is designed as an in-depth study lasting three to four weeks. "A guided-discovery method" of teaching the course is employed, and teamwork and decision-making are emphasized. Computer pre-labs are used to ensure that the students are confident in what they need to do when they enter the laboratory, and interactive videos help them to grasp difficult concepts. Novel computer-based examinations are being developed and tested. The topics of four of the modules include: (1) The Chemistry of the Stomach; (2) Skin Cancer; (3) Lead Poisoning; and (4) Blood Chemistry. The fifth module is designed to expose the undergraduate students to science teaching in the local primary and secondary schools. Each college student observes and participates in a K-12 science classroom, reads articles in science education journals, works with a science teacher in a local school, designs and teaches a laboratory-based project for the K-12 classroom, and participates in discussions and evaluations about the science lesson that has been taught and the conclusions that have been reached about the teaching and learning of science.

Development and Evaluation of Internet-Based Hypermedia Chemistry Tutorials

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DUE-9455382
FY 1995 $ 80,000
Chemistry

The goal of this project is to develop and evaluate Internet-based hypermedia tutorials for undergraduate chemistry courses. The specific objectives are: (1) to develop hypermedia resources that increase the effectiveness and efficiency of student learning and retention, (2) to evaluate and refine hypermedia designs for maximum student use and efficacy, and (3) to evaluate the accessibility of hypermedia educational materials via the Internet for students and educators inside and outside the university. The main advantage of hypermedia educational materials is the ability to link a topic to related and/or remedial material. Having immediate, in-context remedial help will improve the effectiveness and efficiency of a student's study time, and will also reinforce the understanding of basic concepts. The links themselves illustrate the interrelatedness of different topics and the importance of basic principles. This project is expanding the current hypermedia tutorial for instrumental analysis to sophomore-level analytical chemistry and freshman-level general chemistry classes. The chemistry tutorials are viewed with NCSA Mosaic, which is an Internet-based hypermedia browser. It is a multimedia viewing tool with versions for UNIX, Windows, and Macintosh operating systems. Since this project is accessible world-wide via the Internet, it will provide an educational resource for undergraduate chemistry students; K-12, vocational, and college-level educators; and for the public at large. The hypermedia design and Internet access concepts that are developed by evaluating and refining this project will facilitate the creation and distribution of effective hypermedia resources for science education in chemistry and other disciplines.

Molecular Modeling for the Introductory Organic Chemistry Courses

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DUE-9354596
FY 1994 $ 107,736
FY 1995 $ 42,758
Chemistry

The project is developing molecular modeling/computational chemistry experiments for use in first-year organic chemistry courses. Computational chemistry, rapidly becoming an almost routine tool for academic and industrial chemists, allows students to investigate efficiently a variety of molecular attributes including conformational stability, preferred bond angles and lengths, energies of reaction, and reaction pathways. Results provide rationalization of known data, or predictions subject to verification. These benefits accrue only with the aid of a high-quality, integrated visualization environment, a feature central to this project. These experiments are being introduced as hands-on exercises to 240-280 organic laboratory students per year, including chemistry and biochemistry majors and most pre-health profession students. Each year approximately 500 students in the organic chemistry lecture course are being shown the numerical and pictorial results of a variety of pertinent computations. This group of students includes both biology majors and those training for pre-college science teaching careers.

Cooperative Organic Laboratories

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DUE-9455526
FY 1995 $ 159,948
Chemistry

Most traditional organic chemistry laboratories tend to be of the cookbook type. That is, students learn laboratory techniques and then use them to synthesize a given compound in a prescribed manner with a recipe. There is growing unease within the chemical education community about the pedagogical value of such laboratories. In this project the organic laboratory course is being modified by building on the known strengths of the previously-developed cooperative general chemistry laboratory courses. Students work in groups on open ended projects instead of one lab period exercises. Instead of learning a technique as an end in itself, techniques are being learned as a means to an end. Over the course of the semester, students apply their problem-solving skills to projects approximating the research process as closely as possible. The students also use both their written and oral communication skills to plan, critique, and evaluate their experiments. A number of resource materials are being developed including a multimedia program that incorporates video and text so that students can access information in the laboratory, and a laboratory manual that contains a database of typical experimental conditions and work-up procedures in addition to descriptions of techniques. This new lab format will have a significant impact on how students learn organic chemistry and will be particularly beneficial to women. The principal value of this project lies in its application to all organic students, in the expected improved performance and higher retention rates for women, and in its adaptability to other situations.

The Language of Chemistry: Introductory Chemistry Based on the Study of Problems at the Interface Between Chemistry and Biology

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DUE-9354452
FY 1994 $ 75,000
FY 1995 $ 75,000
Chemistry

This project is developing a new introductory course, *The Language of Chemistry*, intended primarily for non-chemistry majors. The immediate challenge is to provide an attractive course that students majoring in areas such as the social sciences and the humanities will elect to help fulfill a distribution requirement. The course illustrates how chemists study problems involving chemical interactions in nature. Among the cases likely to be included for study are the chemistry of gamete attractants; the female pheromone of the silkworm moth; quinine, antimalarials, and synthetic dyes; penicillin; and taxol. Basic concepts in general chemistry and organic chemistry are being developed as required. The methods of analyzing problems are being emphasized instead of the memorization of specific results or formulas. Students should gain an understanding of subjects as diverse as chromatography and other purification techniques, spectroscopy, molecular formulas, molecular structures (and how

chemical and physical methods establish them), stereochemistry, atomic structure, the periodic table, chemical bonding, functional groups, Avogadro's number, and the importance of synthesis. Students, working in small groups, prepare and present short reports on chemical topics, based on library research. The project staff is working with colleagues in the science education department to develop and evaluate the course and related materials.

Transforming Traditional Quantitative Analysis into a Course in Modern Analytical Science

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DUE-9455416
FY 1995 $ 135,214
Chemistry

This curriculum development project transforms traditional sophomore quantitative analysis into a course on modern analytical science. The project is developing a course that emulates the working environment of a modern commercial analytical laboratory. The new lab work reflects a commitment to addressing organic, biological, and environmental studies, in place of much of the traditional emphasis on simple inorganic systems. The types of investigations include: separations science (mixture analysis); multi-element and trace analysis; and combined physical and chemical characterization. Pervading all of this is a laboratory structure based on Federal Good Laboratory Practice Guidelines, where students are responsible for calibration, certification, and documentation. The objectives of this project are: (1) to conduct a realistic experiment in transportability of the restructured sophomore quantitative course; and (2) to produce a laboratory manual which is flexible enough to be useful even at institutions with limited resources. A small but diverse group of interested academic institutions has been enlisted to test transportability at their respective campuses. These schools will also provide feedback regarding laboratory revisions to help accommodate the wide diversity of academic resources. The project was initiated at a summer workshop in 1995 at San Jose State University for all participating faculty. This event will be repeated through 1997, with a viable laboratory manual as the ultimate product.

Improving Student Instrumentation Skills with Pre- and Post-Lab Computer Simulations

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DUE-9455394
FY 1995 $ 60,012
Chemistry

Proper use of instruments is integral to the physical and life sciences, yet many students never become confident or even comfortable operators because of limits on laboratory time and

instrument availability. To introduce principles and procedures before laboratory exercises and to reinforce key experimental ideas after laboratories, a series of interactive computer simulations of laboratory devices and accompanying text materials is being developed. These simulations allow students to explore instrument concepts at their own pace, alone, or in groups. Using an icon-based simulation engine/environment which embodies a block diagram approach, realistic and sophisticated simulations (with on-line help, text and graphical output, and animation) can be created much more rapidly than those written in higher-level languages and can be easily tailored to specific courses and audiences. The exercises promote logical thinking, active learning, and the formulation and testing of hypotheses.

Development of Collaborative, Computer-Networked Laboratories in General Chemistry

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DUE-9455695
FY 1995 $ 135,000
Chemistry

This project provides students with realistic experience in the laboratory of the scientific process and skills for solving real-life problems. The project extends a three-year pilot project that uses collaborative computer-based learning to meet the above goals. Student groups explore the same general problem, but each group uses different reagents. A networked computer system (CoLABnet) is used to collect, pool, and summarize the largely qualitative class data. The pooled data allow the students to examine more parameters with better accuracy than would individual data. The discovery of trends is facilitated by presenting students with multiple instances of the same phenomenon. Groups use commercial graphing software and communicate their findings during a post-lab discussion. Preliminary data from the pilot project indicate that student learning and responses are improved by the new methods. The project evaluates the impact on student learning, evaluates and optimizes the design and implementation of software, develops new software around a commercial database program, and develops and implements a training and support system for TAs. As part of the TA training process, newly developed videotapes dealing with instructional techniques relevant to the collaborative learning classroom are used.

The Integration of Molecular Modeling Across the Chemistry Curriculum as a Tool for Understanding Chemical Structures and for Developing Critical-Thinking Skills

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DUE-9354515
FY 1994 $ 46,172
FY 1995 $ 27,755
Chemistry

Quantitative structure-activity relationships (QSAR) are of concern in many areas of chemistry where the search for specific properties is of particular interest. Because of their importance, structure-property relationships are taught at every level of the undergraduate

curriculum. Although "structure" plays a crucial role in chemistry, it is typically portrayed in undergraduate programs using two-dimensional line figures or hard "ball-and-stick" models. Using the computer to display structure provides an alternative approach. Images can be displayed in three-dimensional space, and variations can be presented to show such properties as charge, isodensity surfaces, or orbitals. However, unless curricular materials are appropriate for a student's stage of development, the use of computer modeling techniques could lead to misconceptions about the nature of the forces that lead to observed structures.

The goal of this project is to develop materials that integrate molecular modeling across the chemistry curriculum. The project plan involves students' use of molecular modeling to learn chemistry while developing thinking skills from simple analysis and comparison through inference, and addresses synthesis of results and evaluation of findings. HYPERCHEM software has been selected for the project. The exercises do not replace a "hands-on" laboratory program. Rather, they are team projects or individual assignments that are done during "open lab" times in the department's computer laboratory. The project begins with in-house faculty development conducted by the project director and a consultant. The faculty also upgrade their expertise by attending an external meeting or conference related to the project. They then work together to develop a coherent set of exercises that build on student background at each level of the undergraduate program. Current chemistry majors are involved in testing the exercises prior to use in each course. These students are hired to serve as laboratory aides during the open computer laboratory hours.

An evaluation process for the project has been designed to establish that the curricular materials are fulfilling the intended outcomes and to determine what additional capabilities of the software can be added in the future. Formative evaluation includes both qualitative and statistical data collected throughout the project and used to modify plans as needed. An external evaluator is being engaged to complete a summative evaluation.

This project focuses primarily on courses taken by first- and second-year chemistry and biology majors and includes selected upper-division courses in which the technique has significant applications. Non-science-majors are also learning to model simple molecules—they are learning science by "doing what scientists do."

This approach is significant in that it calls for integration of modeling techniques across the major program, rather than for use in isolated experiments and exercises developed and used by individual faculty members. It provides a creative means for developing thinking skills and for fostering teamwork. Results are being shared with faculty members in other science departments at Clarke College and at two other local colleges. Project results will be disseminated externally by publication and presentations at professional meetings.

Chemistry Curriculum Innovations: An Integrated Curriculum for First- and Second-Year Chemistry Courses

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DUE-9455718
FY 1995 $ 140,000
Chemistry

A curricular innovation is being implemented to address the problems of the traditional sequence of a year of general chemistry followed by a year of organic chemistry. These problems

include: an artificial segregation of inorganic and organic chemical concepts; a large emphasis on quantitative skills one year and qualitative skills the other; introduction of theory prior to its empirical basis and unrelated to laboratory experience; and a perception by students that chemistry is disjointed, lacking both continuity in its presentation and relevance in its application.

There are three critical components to this renovation of the curriculum: (1) to integrate inorganic and organic chemistry throughout both introductory and intermediate chemistry; (2) to fashion a laboratory sequence that promotes student understanding of the qualitative and multidisciplinary aspects of chemistry, including the use of modern instrumentation beginning in the first semester; and (3) to create lecture and laboratory texts for use with such innovations. A unique advantage of this sequence, absent in the traditional, organic first, and two cycle approaches, is the overall matching of topic development to student ability over the two year sequence. This approach builds, from an empirical basis, those unifying concepts of chemistry throughout a two-year sequence. By removing the barriers separating the branches of chemistry at the introductory and intermediate levels, students have a more integrated view of the subject, and have fundamental concepts reinforced with the widest possible variety of chemical examples and explanations.

The success of this innovation is being evaluated by measuring both student satisfaction and student comprehension. Student satisfaction is determined qualitatively by response to questionnaires and quantitatively by the attrition rate after each of the four semesters. Student comprehension is measured via standardized ACS exams.

Texts are being made available for use at one or more alternate test sites, and both the texts and evaluations are being reviewed by an independent advisory committee of experts in chemical education from small, medium, and large colleges and universities. This model of curricular innovation was presented for discussion at the 1995 meeting of MACTLAC. Colleagues are being recruited to critically evaluate the texts as they are produced. Adoption of this innovation at alternate trial sites is being encouraged to help assess its utility, and findings will be published.

Theme-Based Bidisciplinary Chemistry Laboratory Modules

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DUE-9455693
FY 1995 $ 25,596
Chemistry

The fundamental tenet of this project is that student interest in science will be aroused and student understanding of the scientific method will be enhanced by the introduction of multiweek bidisciplinary laboratory modules at the end of each semester in the introductory chemistry sequences—general and organic chemistry. The laboratory modules are organized around themes that have broad-based relevance: water analyses due to environmental concerns; plant assays in response to environmental matters and biochemistry interest; and drug design in recognition of the large pre-medical student population among the students enrolled in the introductory chemistry courses. The laboratory modules are designed to imitate aspects of research by allowing students latitude in formulating specific goals for the project. This is done by incorporating a longitudinal component to the study for the establishment of a qualitative and

quantitative database, and by forging research teams both within the individual teaching laboratories and also by bridging student groups across courses in related science disciplines, such as chemistry and biology or geology.

After completing the bidisciplinary laboratory modules, students communicate their scientific results at a poster session. The exchange of ideas that results from the poster session will further encourage student involvement. It is hoped that the bridging concept will find universal adoption at the college and will thus serve as a general pedagogical paradigm for an efficient, logical utilization of the multidisciplinary approach to teaching science.

A group of ten faculty from five science departments constitute an internal advisory committee for program evaluation. After program testing is complete, the advisory group will be expanded to include science faculty from other institutions.

Dissemination of results will occur via presentations at national ACS meetings by publication of laboratory modules.

A New Investigative Laboratory for Introductory Organic Chemistry Involving Polymer Synthesis and Characterization

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DUE-9455681
FY 1995 $ 70,000
Chemistry

The project addresses flaws in experiments commonly taken from a laboratory textbook (often called cookbook) which fall short of providing exciting and intellectually stimulating experiences. To remedy this situation, the project is developing a model comprehensive organic laboratory curriculum that gives students the opportunity to be imaginative and creative, leads to better understanding of the concepts that underline scientific research, and is an important connection between theoretical and practical organic chemistry. Individual exploratory research projects are designed for the last quarter of a three-quarter laboratory course that integrates the instructor's research interests with learning experiences for the students. The vehicle is individual organic and polymer syntheses that combine classic organic chemistry and polymer chemistry. The course is structured in a guided discovery model. Each student, in a problem-solving manner, utilizes his or her knowledge and skills learned from the previous two parts of the lab sequence to prepare a monomer via an organic synthesis and a polymer by a polymer synthesis. The research is an open ended laboratory project which includes a microscale monomer synthesis and characterization, scale-up synthesis and characterization, and polymer synthesis. By changing functional groups on the vinyl monomer molecule, the class can explore the reactivity of one "family" of compounds and, subsequently, polymers. This provides the opportunity to make some rough structure-reactivity correlations at the end of the course during group discussion in the class. Pedagogically, this approach makes a point that chemistry is an experimental science in which one can test ideas about both structure and reactivity. The project addresses the improvement of the quality of the undergraduate organic laboratory course model which simulates research activities in the interdisciplinary field of organic chemistry and polymers in three needed areas: the articulation of the instructional model more clearly; the enhancement of the laboratory instruction with the use of computers; and the development of tutorial resources as remedial support for students. Efforts at improving and assessing the value of this curriculum in ways that inform the development of the

course and guide research on the learning outcomes will continue. The project also involves the dissemination of the model, highlighting curriculum design and instructional underpinnings to fellow colleagues, as well as to colleagues on the national level, through presentations at local and national conferences and through journal articles.

The Inorganic Illustrator: a 3-D Graphical Supplement for Inorganic and Bioinorganic Chemistry Courses Distributed on CD-ROM

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DUE-9455567
FY 1995 $ 134,989
Chemistry

The visualization of complicated three-dimensional inorganic, bioinorganic, and solid state chemical structures is a particularly difficult problem when the primary means of communication is the two-dimensional world of textbooks, blackboards, and overhead projector screens. Due to the increased performance and availability of personal computers, both instructors and students are beginning to embrace interactive multimedia as a means of communicating chemical information. The goal of this project is to provide on CD-ROM a wide variety of manipulatable molecular models, miniature movies, and dynamic animations that address the topics in inorganic and bioinorganic chemistry that will most benefit from a multimedia format. The free software Chem3D Viewer is being used to present a database of hundreds of accurate crystal structures that will benefit students and teachers at all levels who encounter inorganic structures. Stand-alone tutorials that describe the use of the software and explain difficult structural concepts of inorganic chemistry are being produced. Dissemination of test versions will be via the Internet, followed by the complete version on CD-ROM, and evaluated by polling users at a variety of small and large institutions.

Development of a Set of Closed Laboratories for an Undergraduate Computer Science Curriculum

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DUE-9156112
FY 1992 $ 204,514
FY 1993 $ 200,334
FY 1994 $ 200,152
FY 1995 $ 64,548
Computer Science

As a discipline, computer science has seen many dramatic changes in its brief history. Through new textbooks and an evolving curriculum, the content of the undergraduate computer science education has, for the most part, kept pace with these changes. But its pedagogy has hardly changed. It emphasizes individual skill in writing, from scratch, small programs in an obsolete language. This emphasis is the antithesis of what is needed by contemporary computing professionals. This project is developing and evaluating a new undergraduate curriculum and supporting materials focused around the practice of computing, especially in the first two undergraduate years. This pedagogical shift has enormous potential for improving undergraduate computer science education.

The focus of the new curriculum is a core sequence of closed laboratories. Lecture content and materials support the laboratories instead of the reverse. While content can always be improved, quantum improvements cannot be expected. Laboratories, by contrast, have been largely neglected in this "laboratory science."

The Department of Computer Science is developing a "practice-centric" undergraduate computer science curriculum. Specifically, it is developing a collection of laboratory materials and exercises that support this approach. Also central to this approach is an increased degree of rigor in all courses, coupled with the early introduction and subsequent use of modern software development methods and tools.

In the new computer laboratory, furnished with state-of-the-art hardware and software, students work together through a series of exercises designed to encourage teamwork and brainstorming while reinforcing course content. These exercises are based on large hardware/software systems, incorporating actual industrial/corporate hardware and software products. The results of students' work are exhibited and critiqued by peers. The exercises also employ the case-study model to facilitate understanding of an entire system with fun equipment, such as sound generators and robot arms, that is available for laboratory projects. The use of advanced CASE tools also is part of laboratory exercises.

Each laboratory exercise, as well as the overall curriculum, is being evaluated using surveys, pretest/post-test, interviews, etc. Evaluation is done on a continuous basis for each set of closed laboratory exercises, allowing modification of the material over several groups of students. Questionnaires for graduates and their employers provide needed information about the long-term benefits of the revised undergraduate computer science curriculum. When the initial sequence of introductory courses has attained the stated objective, beta tests of the materials will be conducted at other schools. This closed laboratory approach provides students with more real world experience while learning the basic tenets of computer science.

"This-is-how-a-computer-works": A Software System for Lecture Demonstrations, Laboratory Exercises, and Home Study

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DUE-9455507
FY 1995 $ 100,000
Computer Science

This project continues ongoing work to create a simulator for an idealized computer that enables students to see its internal workings as it executes a computation. The student can observe the compilation process as a higher level language is translated into assembly language. Then he or she can watch the resulting assembly language executed on the architecture at the register level. Finally, the system can display one of the functional circuits (the adder) at the switching circuit level and one can watch switches turn and the electricity flow as the computation proceeds.

The system offers the user the option of calling for a tutorial description of the individual steps as they proceed. On the appropriate menu call, a little professor jumps onto the screen, and in cartoon style, describes the events of the computation. The system is designed to be used by a lecturer on a wide screen display during a class, by students in laboratory sessions, or as a home study aid. The system is being tested on a group of thirty students and their levels of achievement in learning how a computer works will be evaluated. It is available to any potential users via ftp and has been described in numerous papers and presentations to the community. The system should be a powerful aid in the teaching of the principles of operation of modern computers.

Integrating Social Impact and Ethics into the Computer Science Curriculum

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DUE-9354626
FY 1994 $ 43,744
FY 1995 $ 55,000
FY 1996 $ 40,000
Computer Science

The purpose of this project is to develop a plan and materials for integrating social impact and ethics topics across the computer science curriculum. It addresses two major problems that hamper the implementation of an across-the-board curricular change: (1) the lack of materials that can be adapted or adopted into the existing computer science (CS) curriculum; and (2) the lack of awareness and expertise on the part of most CS faculty regarding the need and methodology for presenting such material in their courses. The project comprises three interrelated tasks: (1) defining the content of teaching modules to facilitate the presentation of these topics; (2) developing the actual modules to be disseminated as a teaching kit to interested CS departments and faculty members; and (3) developing a pilot faculty enhancement seminar to prepare interested CS faculty members to use the materials. The first task is to implement a two-day working conference of experts in ethics, social impact, and computer science curriculum to determine the appropriate content for the teaching modules. Topics for a first-year computers-and-society course, the traditional computer science core courses, and the senior design course

are being discussed. The anticipated outcome of this conference is a consensus regarding which topics, how much time, and the level of such topics that should be included in the CS curriculum. The second task is to implement the teaching modules that result from the working conference. These modules include scenarios, exercises for discussion and written comment, and teaching strategies for presenting the topics. The modules are being developed for a first-year course, for computer science core courses, and for a senior design course. These modules will be sent out for comment and pilot testing by computer science professors. A kit of teaching modules is being developed for general dissemination. The third task is to implement a pilot two-day faculty enhancement seminar to provide guidance to CS professors regarding effective use of the materials. Based upon results from the pilot seminar, a kit for faculty enhancement seminars will also be developed for general dissemination.

Educating the Next Generation of Information Specialists, in Collaboration with Industry

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DUE-9455450
FY 1995 $ 161,850
FY 1996 $ 151,463
FY 1997 $ 153,682
Computer Science

This work produces a greatly needed and major revision (or complete revamping) of Computer Information Science (CIS) oriented curricula. Specifically it provides detailed curriculum guidelines, supporting laboratory material, original learning/teaching paradigms, and a methodology for dealing with complex information systems. This major component of the computing sciences has been overlooked by practitioners, educators, and the professional societies for at least 15 years. During this same period the need for complex, large grain information systems to support all aspects of business, industry, and government has exploded; similarly, the technologies supporting the generation and usage of information have changed dramatically. This has led to the current dilemma: the availability of exciting new information technologies to be applied, but few new hires or practitioners, if any, properly prepared to effectively apply these advances. This academe/industry collaborative project addresses this dilemma, and will produce solutions. The work builds on what is available today in CIS, adding to it substantial new course and laboratory material, a methodology for dealing with large grain information system complexity, development of teamwork and communications skills in students, and embeds problem-solving and design skills within the recommended curriculum. To support this curriculum, appropriate materials are developed and tested at selected university/industry test sites. A new learning/teaching paradigm (i.e., Just in Time Learning) is developed and tested, in which qualified students (guided by a faculty member) are electronically linked with an ongoing industry large grained information systems project. There are participating project team members, receiving both project experiences and Just in Time classroom/laboratory experiences. The Boeing Company and Motorola are committed to supporting this original learning/teaching paradigm. Three eminent CIS specialists form the National Visiting Committee to critique and guide the project, and 50+ additional external specialists will review the results of the project. In this manner, the quality and applicability of

project results are assured. Widespread and timely dissemination to the computing profession will be conducted.

An Interactive Laboratory Infrastructure for Computer Science

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DUE-9455588
FY 1995 $ 93,344
Computer Science

The objective of this project is the design and development of an infrastructure around which formal laboratories in computer science can be implemented. The central component of the infrastructure is a software system called DYNALAB, for DYNAmic LABoratory. DYNALAB currently runs on IBM-compatible personal computers under Microsoft Windows (with the Win32 extension) or Windows NT, as well as UNIX-based XWindows systems. Students using DYNALAB have access—through a user interface oriented towards complete novices—to a comprehensive, easily modifiable, and extendible library of programs and experiments, including experiments in program structure (e.g., iteration, selection, recursion, execution-path determination, parameter passing mechanisms, functions, and procedures), black box determination of algorithms, time complexity, space complexity, program verification, and others. A sophisticated program animation component allows the execution of programs both forward and in reverse, while displaying dynamically and in interactive fashion the pertinent aspects of program execution, such as the currently executing statement, values of variables, pointer references, and statement and memory cell counts (for time and space complexity experiments). An algorithm animation component also allows abstract graphical representations of algorithms to be presented on a screen in forward and reverse modes for algorithm and data structure studies. Eventually, concept animations will be included for the study of fundamental computer science concepts, such as compiling, multitasking, and intractability. The desirability of formal laboratories in the computer science curriculum is well-documented, but few institutions have incorporated them for lack of laboratory resources. DYNALAB represents one such resource. DYNALAB will be distributed as an ancillary to textbooks in programming, as well as data structures and algorithms. It will also be available on the Internet, following links beginning with http://www.cs.montana.edu/~ross. It is expected that DYNALAB will be widely adopted as a tool around which computer science laboratories can be designed.

Program Derivation for a Data Structures Course

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DUE-9455660
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Computer Science

Computer programming is often taught primarily by example, and there is widespread interest in more systematic methods, especially mathematically rigorous "formal methods." There are now undergraduate level textbooks and teaching materials for beginning programming courses using the method called program derivation, whereby correct programs are derived from

their specifications by calculation. The objective is to develop lecture notes and programming assignments for an undergraduate data structures course based on program derivation. The materials are based on materials now being used in the classroom, and will be evaluated by educators at other universities for content and suitability for use in undergraduate courses in data structures. By meeting the need for instructional material based on the extensive research literature on program derivation, this project will directly benefit educators who wish to teach scientifically-based systematic methods of programming. By providing material on par with textbooks for the more traditional approach, this project will help to provide a basis for meaningful comparison between curricula based on formal methods and other curricula.

Cognitive-Based Approach to Introductory Computer Science Courses

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DUE-9455522
FY 1995 $ 89,976
Computer Science

A cognitive-based approach is used to develop comprehensive materials for the first courses in computer science based on Implementation D of Computing Curricula 1991. The distinguishing features are: (1) materials based on a strategic sequencing and the associated level of mastery of key topics, (2) a topical coverage carefully based on a spiral approach to information presentation, (3) an integral use of structured labs as a necessary component, (4) an emphasis on frequent feedback to facilitate learning and evaluate the effectiveness of instruction, (5) remediation materials for students requiring additional assistance to meet the required levels of mastery, (6) an early use of teams, (7) a student surveying tool used to track all students to provide outcome assessment, and (8) review and evaluation by multiple institutions for iterative material refinement and national dissemination. The project is being carefully evaluated by a team of eight consultants with expertise in the fields of computing, computing education and educational psychology. The materials developed are also being critiqued by professionals at a wide variety of other institutions for their input as to the applicability of the materials to students at their institutions. The resulting materials will be made available in hard copy and through electronic media.

Pattern-Based Programming Instruction

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DUE-9455736
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Computer Science

A detailed course outline for a pattern-based introduction to computer programming is being developed. The course begins with a statement of theory and principle that both explains and guides the rest of the work. Common types of computing problems that provide coverage of

typical programming course content are being identified. Next, one or two examples for each problem type that will be used to illustrate the basic algorithmic pattern are chosen. A number of alternate problems requiring modifications of each basic pattern is being identified and the course outline is being finalized.

Three activities are being used to assess the course: (1) Faculty perceptions as to effectiveness, coverage of material, ease of use, student progress, etc., is being noted. (2) A questionnaire is being developed and administered to address student perceptions of their own understanding and their comfort with the approach. (3) Questions common to final examinations for various programming courses are being compiled and the effectiveness of this approach to that of traditional instruction is being compared. After assessment and revision as called for, at least one additional course will be offered using the same approach, but perhaps a different language.

Papers and presentations will be produced and submitted to appropriate computer science education journals and conferences. The theory and principles involved in the approach, as well as descriptions of the curriculum, will be addressed.

The instructional material will provide a solid testbed for further research and explication of standard problems and programs in computing. The pattern-based approach should significantly improve the quality of programs produced by students after a first course. While this project does not focus on any special audience, its approach to programming instruction should ultimately enhance both attraction and retention of all students, including women and minorities.

A Second Course in Computing for Non-Majors

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DUE-9455635
FY 1995 $ 85,835
Computer Science

Information will be the coin of the realm in the 21st century, and learning to locate, evaluate, utilize, and disseminate it will be at the very center of the university's mandate. In the past, only some science and engineering students needed extensive high level computing skills; however now, and increasingly in the future, fluency with computational environments will be a decisive factor in both academic and commercial success. As a sequel to the PI's highly successful first course for non-computer majors, sponsored jointly by NSF and the Department of Education, this second course, which focuses on the acquisition and presentation of data and information, is being developed.

For data acquisition, the course gives the students high level mastery of the Internet. For the presentation of information, students master a multimedia authoring system. The Internet segment of the course focuses on the following topics: (1) what is the Internet and what is it not; (2) resources available on the Internet for teaching and research in various fields; (3) where to locate additional information; (4) navigating the Internet via Gopher, Archie, Veronica, WAIS and WWW, e-mail, FTP, Telenet and List servers; and (5) using USENET, setting up news groups and IRC on an Internet node set up and maintained at the College.

The multimedia segment of the course uses the Toolbook environment from Asymetrix Corporation and focuses on how to construct simple "books" with hot keys and buttons, how to

create multipage branching books, how to create motion and animation, how to design and create hypertext systems, how to design and create interactive multimedia, and how to program sophisticated multimedia applications within Toolbook.

Computer-Based Laboratories for Introductory Computing Courses for Science and Engineering Majors

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DUE-9455478
FY 1995 $ 87,125
Computer Science

In traditional science and engineering degree programs, computation is commonly treated as a problem-solving tool best studied and applied in isolation from "real" science and engineering. Students are typically required to take a programming class to learn how to program, and perhaps a numerical analysis class to learn how to apply their programming skills. This traditional approach ignores the fact that computation has evolved into an essential way of illuminating scientific and engineering principles. Researchers now choose among the theoretical, experimental, and computational approaches to studying scientific phenomena. It has become increasingly clear that computation should be exploited in science and engineering education for its descriptive and analytical powers. In the past, the barriers to using computational techniques were high. The emergence of application programs such as *Maple* and *Mathematica* has greatly lowered these barriers. The computational power made available per unit of student effort is orders of magnitude higher for these packages than it is for traditional programming languages. This project is developing a suite of computer-based laboratories suitable to support a two-semester freshman/sophomore-level computing course for science and engineering majors. Each laboratory illustrates the computational solution of a typical problem from a field of science or engineering, builds upon freshman-level concepts from mathematics and physics, and leads the student through the process of learning the computing technology (including mathematics packages and conventional languages) required to solve the problem. Workshops will be conducted annually to train undergraduate faculty in the use of the course materials.

A Hypermedia Lab Manual for Operating Systems

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DUE-9455307
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Computer Science

Sending students to a local copy center to get copies of class handouts is an inefficient, high cost method of distributing class handouts. In addition, the full impact of algorithm animations such as the dining philosophers cannot be captured in snapshots on paper. What is

needed is a method of making handouts and documents available to students that does not use paper, does not cost money, is not limited to plain text, contains more than just algorithm animation snapshots, and facilitates ease of access throughout the university network. The goal of this project is to transform some operating systems and concurrent programming handouts into a hypermedia laboratory manual residing in files accessible by Drexel students from any network location. The files are written in Hypertext Markup Language (HTML) and contain hyperlinks to program source code, screen snapshots, and movies of algorithm animations in MPEG or QuickTime format. Students use a World Wide Web browser program such as Mosaic to access the lab manual via Hypertext Transmission Protocol. Since the Drexel dormitories are now on the network, students are able to access the lab manual from their rooms using their Macintoshes. Feedback will be solicited on the ease of use and effectiveness of the hypermedia lab manual from Drexel students as well as from other students and faculty accessing the lab manual over the Internet. The hypermedia lab manual will be made available over the Internet to operating systems and concurrent programming students and faculty at other institutions. Such availability will be announced in several relevant USENET newsgroups. A description of the project and its results will be submitted for publication and presentation at a conference. This is an innovative use of the university computers and network to make handouts and other documents available to students in an efficient, low cost manner. Students and faculty at other institutions on the Internet will also be able to access this hypermedia operating systems lab manual.

An Assertion-Based Programming Methodology for Introductory Programming Courses

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DUE-9455489
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Computer Science

A perusal of current introductory programming texts shows that while the syntax of structured statements is described in formal terms, the semantics of structured statements is described in informal verbal terms. The result is that students leave introductory programming courses with a good understanding of the syntactical aspects of structured programming and a poor understanding of the semantical aspects. The programmers will have difficulty assessing either formally or informally the correctness of software which may control critical computer systems. The goal of this project is to develop and assess a programming methodology for the introductory programming sequence, based on a blend of operational and axiomatic semantics, which integrates semantic content (in terms of assertions) into the programming process.

A textbook which presents the methodology is being written and assessed. The text is language-independent and useful as either a stand-alone or a supplement to an existing introductory programming text. The impact of this project is on four groups. (1) Instructors of introductory programming courses are able to integrate the semantic-based methodology into their existing courses without changing the primary text: the supplementary text provides them formal support for integrating the methodology. (2) Students learning the methodology via the supplementary text gain more thorough understanding of the program semantics because the semantics are presented formally in terms of assertions. They are better equipped to convince

themselves and others that their programs are correct because their programs carry the evidence. (3) Students, instructors, and computing professionals who have not had the advantage of a semantic-based programming methodology will be able to use the text to familiarize themselves with the more formal semantic side of programming. (4) Finally, the public will be long-term beneficiaries of the project.

The GeoSim Interface Library for Introductory Programming Courses

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DUE-9455403
FY 1995 $ 19,768
Computer Science

The GeoSim Interface Library (GIL) provides a common set of Graphical User Interface (GUI) functions for programs running under the MS-DOS, Macintosh and XWindows programming environments. Application program software is written to access GIL. In this way, programs need only be written once to run under these three programming environments. GIL handles most typical GUI tasks, such as window display; backing store management for overlapping windows; and mouse interaction with buttons, drag regions, lists and sliders. GIL supports "help screens" and "alert boxes." GIL also includes additional support for non-typical applications development features such as log files, data file processing, and time-driven functions independent of user interface objects and actions (used for discrete event simulations). Existing GUI development systems do not provide the multi-platform capability necessary for our diverse student population. Fortunately, GIL has proven to be easy to use by students and researchers alike, and can easily be adapted to class use. This project seeks to obtain the modest manpower resources necessary to make GIL a tool that can be used by undergraduates in introductory programming courses. GIL provides a GUI library for use in writing class programming assignments. Use of a GUI in introductory programming classes allows students to begin early practice in writing applications programs more like what they will do in their jobs. Enhancements to the GIL system include a Graphical Interface Developer that allows students to interactively place user interface elements on the screen, better support for fonts and window backing store, and classroom-ready documentation and examples. GIL, including source code and documentation, will be freely distributed via tabs Internet.

Development of Lecture Room Demonstration Experiments to Improve the Computer Literacy Course

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DUE-9455314
FY 1995 $ 59,121
Computer Science

Lecture room demonstration experiments, which actually show how things work, are relatively new to computer science educators. In most other fields of science, demonstrations have proven quite effective in combination with a variety of teaching methods and have been

successfully used for many years. Such "live" demonstrations, especially for introductory classes, awaken a keen interest in the "chalk and talk" lecture and tend to be remembered long afterward. Lecture room demonstrations need to be considered seriously as a teaching aid for helping to revitalize introductory computer science courses. The real problem is that very few instructional materials are currently available on this subject. This project addresses the need to develop computer science lecture room demonstration materials. More specifically, it concentrates on development of eight innovative, low cost, computer hardware-related lecture room demonstration experiments to improve the computer literacy course taken by non-computer science majors. These demonstrations help students to better understand basic concepts of how computers operate and permits them to see firsthand, a number of attention-grabbing, real-world applications. Students learn that computers are used for more than just running software applications. The demonstrations show students how computers and peripherals work; illustrate aspects of telecommunications and networking; show actual business and industrial applications; and present emerging computer-related technologies such as multimedia, hypermedia, and virtual reality. Details of how to build and set up the demonstration apparatus, teaching techniques, and results from classroom trials are made readily available via pamphlets, presentation at workshops, and the Internet. This project is expected to be of great interest and benefit to all teachers of the computer literacy course.

Using Iconic Environments to Teach Procedural and Object-Oriented Programming Concepts

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DUE-9455614
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Computer Science

This project addresses the question: Can icon-based programming languages be used to teach first-year programming concepts to undergraduate students more effectively than text-based languages? The specific objectives are: (1) To develop a complete set of course materials for BACCII, an already-existing iconic programming environment under ongoing development at Texas Tech University, and use them in the first two computer programming courses. For this project, the first course is an introduction to procedural programming, software engineering, and C++, while the second course teaches concepts in object-oriented programming and data structures, also in C++. (2) To determine whether iconic environments (and BACCII in particular) can be used to more effectively teach procedural and object-oriented programming concepts in the first two courses, while still allowing students to learn the syntax of text-based languages such as C++. This project is testing the course materials at Texas Tech, while a possible later project would allow for pilot programs to be started at five higher education institutions. Data will be collected and evaluated not only for the general student population of each course, but for various groups such as women, underrepresented minorities, and future teachers. (3) To advance research in the area of using iconic programming languages as learning environments. The results of the data from Texas Tech and the other five pilot programs will allow for an evaluation of how future iconic languages for learning programming skills should be developed. If it can be demonstrated that iconic languages perform significantly better text-

based languages in the learning of programming skills for a wide variety of schools and student groups, it could revolutionize how software development techniques are taught.

Technology in Teaching and Research: A Look at Private Education in Appalachia

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DUE-9554456
FY 1995 $ 19,166
Computer Science

This ambitious, long-range project is designed to unite the efforts of faculty in private colleges across the Appalachian region to strengthen their use of technology in the undergraduate curriculum. The first step in the project, "A Look at Private Education in Appalachia," is to determine what technology is currently in place and how faculty are using it in their classrooms, both for instruction and research. The study is expected to show that while many of the Appalachian colleges and faculty are seriously lacking in the resources necessary to employ technology to strengthen their instruction, in far more cases the colleges and their faculty are on the edge of excellence in their access to and use of technology. At the end of the study, a college or faculty member will be able to examine itself or himself in view of what is happening at like institutions. The college will be able to determine what is necessary to strengthen its competitive edge in recruiting and maintaining students, and the faculty will be able to identify other faculty across the region who share their interest or who can strengthen their knowledge and skills. The final report documenting the results of the study will be available for dissemination to colleges across the nation who may also want to prepare for the 21st century.

Video Resources for Instruction in Introductory Engineering Thermodynamics

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DUE-9254005
FY 1993 $ 105,984
FY 1994 $ 99,255
FY 1995 $ 10,000
Engineering

This project is producing a series of 11 videotapes for use in undergraduate instruction in introductory engineering thermodynamics. The tapes use a combination of live-action video to illustrate important applications of thermodynamics and computer-generated graphics to illustrate fundamental concepts. Historical background on important people and events in the development of thermodynamics also is presented. Topics covered in the programs include energy, heat and work concepts, thermodynamic properties and processes in gases, liquids and mixtures, energy transformations and First Law analysis of closed and open systems, reversibility and irreversibility, Second Law analysis and entropy, isentropic processes and component efficiency, Carnot and thermodynamic cycle performance, and principles and applications of various power and refrigeration cycles. The tapes are being used in several core thermodynamics courses at the University of Texas at Austin with a total enrollment of 800 students annually. They will also be made available for use in a pilot evaluation at five other universities, and subsequently will be distributed nationally on a low-cost basis. When used nationally, these materials could impact more than 25,000 engineering students per year in introductory thermodynamics courses.

Design of Electromechanical (Mechatronic) Systems: An Integrated Interdepartmental Curriculum

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DUE-9354403
FY 1994 $ 100,000
FY 1995 $ 10,000
Engineering

The principal goal of this project is to develop an innovative curriculum in Electromechanical (Mechatronic) System Design that integrates electrical, electronic, mechanical, and computational engineering by introducing videos and computers into the classroom and laboratory. The curriculum emphasizes the use of a variety of CAD tools in engineering design and analysis and provides a realistic setting in the laboratory that enables students to address design and experimental issues in engineering. This integrated curriculum cross-lists many relevant electrical engineering and mechanical engineering courses and develops a Motion Control in Electromechanical Systems Laboratory that exposes students to the electrical, electronic, mechanical, and computational aspects of motion control and hybrid-electric vehicles. Students electing this curriculum receive a certificate of study in Electromechanical System Design and complete their senior design projects using the facilities available in the laboratory. Through this curriculum, undergraduate students complete capstone design projects in electromechanical systems. The design projects are realized through open use of the laboratory and with the participation of industrial sponsors who assist in defining projects.

Development of Materials Synthesis Courses and Their Innovative National Dissemination

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DUE-9354440
FY 1994 $ 47,795
FY 1995 $ 45,000
Engineering

There is a national consensus, as shown in the National Academy's 1989 study on Materials Science and Engineering, that the U.S. lags behind its competitors in the field of materials synthesis and processing.

Over an 18-month period, this project is developing two new courses in the area of ceramic materials synthesis. The courses are at the senior level, but also could be used for beginning graduate students and in industry. To encourage adoption of the courses, distinguished scientists from around the world will teach the classes, whenever possible.

The use of the Video Tape Live Audio (VTLA) method makes both the content and the delivery system a national model. VTLA involves a course videotaped in a studio (with all backup in the parallel text and readings) followed by a weekly 1-hour audio-only tutorial by the same teacher/lecturer. The VTLA process allows a university to expand the student body served to the national cohort by working with sister departments. This approach is also significant for faculty enhancement in fields where there is an identified shortage of faculty with adequate training, a situation true of ceramics in general and ceramic materials synthesis in particular. The project begins with faculty at Pennsylvania State University and is augmented later with distinguished international leaders in related fields. The initial group of participating departments was between six and ten for the first course (Spring 1995). Solicitation is accomplished via mass mailings and announcements in professional journals. Evaluation involves both formative and summative mechanisms, and results from course evaluations by both students and faculty will be included in final reports.

Enhanced Curriculum for Undergraduate Engineering Adult Learners in Industry

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DUE-9455466
FY 1995 $ 319,940
Engineering

In 1988, the School of Engineering and Mines of the University of North Dakota, in a partnership with industry, established three distance-learning undergraduate engineering programs: Chemical Engineering; Mechanical Engineering; and Electrical Engineering. This initiative gave access to an engineering education to students who, because of locations and schedules, otherwise could not pursue an engineering undergraduate education.

The distance-learning students, by virtue of their maturity and paraprofessional experience, have needs, expectations, motivations, knowledge, and skills which differ from those of traditional students. Thus, the curricula must be modified to meet students' needs efficiently, incorporating their experiential knowledge and skills, while simultaneously ensuring validated

compliance with ABET accreditation standards. It is also critical that faculty develop strategies for attaining maximum teaching effectiveness in the distance-learning environment.

The three-year collaborative project addresses the following goals: complete a comparison of a broad range of cognitive and performance-based competencies of distance-education students and traditional students; enhance the curriculum to meet the unique needs of adult learners while adhering to ABET standards; develop faculty members' competencies needed to enhance teaching of non-traditional learners; evaluate program outcomes using qualitative and quantitative techniques; and disseminate results which document the evolution of an ABET accredited, undergraduate distance-learning program in engineering. The objectives are: (1) define what it means to be an engineer (focus groups, written questionnaires, and telephone interviews); (2) evaluate the current undergraduate engineering curriculum; (3) assess the competencies and knowledge base of distance-learners (problem solving/critical thinking, oral, written and listening communication skills, teamwork, computer literacy, research skills, self-directed learning, professional conduct, and flexibility); (4) determine gaps in the curriculum; (5) modify curriculum and design formal faculty development activities; and (6) continue to assess students' cognitive and performance outcomes (portfolios, interviews, written and oral assignments, and essay tests). Anticipated program outcomes include validation that the distance-learning program can effectively meet ABET accreditation requirements, evolution of enhanced techniques for measuring learning outcomes, and development of efficient and effective design and professional practice courses for distance learners.

Engineering, Technology and Culture: with an Emphasis on Race, Gender and the Individual

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DUE-9455422
FY 1995 $ 64,210
Engineering

The aim of this project is to make the social sciences and humanities more meaningful to engineering students, including women and underrepresented minorities. It is an effort to reform undergraduate engineering education by offering a unique interdisciplinary and multicultural diversity engineering course as part of the general education curriculum. The course, entitled "Technology and Culture", places specific engineering designs within the social and political context of race, gender and individuals. The course is designed to give technical students a better understanding of the cultural, historical and political context of their disciplines. At the same time it gives humanities and social science students a better understanding of the methods and capabilities of science and engineering. The project promotes new interdisciplinary teaching methods and encourages faculty to experiment with different ways of incorporating multicultural diversity and gender issues into their courses. It enlists the cooperation of faculty, departments and committees across the colleges of engineering and the liberal arts and sciences. It reinforces this cooperation through a series of faculty development workshops emphasizing cultural sensitivity training and interdisciplinary teaching methods. The project also serves as a catalyst for reform for the teaching of other courses that integrate engineering and science with disciplines in the humanities and the social sciences.

Enhancing the Environmental Content of Undergraduate Engineering Curricula

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DUE-9455399
FY 1995 $ 188,860
Engineering

This program introduces environmental issues into the curriculum of each traditional engineering discipline at Carnegie-Mellon University (CMU), focusing on the freshman and sophomore years. It enables students to gain exposure to environmental concerns and problem-solving methods in their discipline. Environmental units that can fit easily into several existing required courses are being developed, which form the basis for subsequent efforts focused on junior and senior-level courses as a follow-on to the current project. Throughout this effort, course materials that can be widely disseminated to other U.S. engineering colleges and universities are being developed. This approach is favored over the development of new or required environmental courses for several reasons. One is that modern engineering curricula already have a surfeit of competing demands for new or specialized courses; therefore, as a practical matter, it is difficult to introduce new requirements into the curriculum at most institutions. More importantly, however, environmental issues should not be seen as distinct from "mainstream" engineering issues. By integrating environmental considerations into basic engineering courses in each discipline, all engineering students will come to see that environmental factors are an inherent part of good engineering practice. Relatively small modifications in the curricula of existing core courses can have a significant impact on the environmental education of all engineers, not just those who choose to specialize in environmental engineering.

Undergraduate Curriculum Development on Mechatronic Systems Engineering

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DUE-9455395
FY 1995 $ 290,000
FY 1996 $ 113,280
FY 1997 $ 90,999
Engineering

The goal of this project is to satisfy an urgent need by industry for BS engineering graduates with multidisciplinary knowledge and skill in mechanical, electronic, computer and industrial and systems engineering. This need is becoming more urgent to the U.S. manufacturing industry than ever, due to the complexity of its products, and the global competition in marketing manufactured goods.

The aim is to develop an ABET accreditable curriculum stem on mechatronic systems engineering in the mechanical engineering department consisting of five new courses and a new Mechatronics Systems Laboratory. These courses are being adopted as electives by other participating departments of electrical, computer, general and industrial, and systems engineering. The Physics Department will use the laboratory for instructions on electronics and mechanical systems for lower division engineering students.

Two of the five new courses and the laboratory are being developed in the first of the three-year period. Faculty members from all participating departments are involved. The project is expected to be completed in February 1998. An Advisory Committee chaired by a senior leader from the local mechatronic industry has been established to oversee the progress. Membership of that committee includes three other leaders from the same industry and administrators from the College of Engineering. A professional evaluator has been hired to evaluate the progress of the project on an annual basis.

Results will be disseminated through conferences on engineering education, publications in relevant journals, and conference proceedings. Faculty Enhancement Workshops on the subject development have been scheduled for the Spring 1996 and the Fall 1997. Course outlines, printed notes, and lab manuals will be made available to institutions that are identified as potential beneficiaries of this development. Selected case studies and lab procedures will be documented in CD-ROMs which can be distributed through electronic links to receiving institutions, or through the National Engineering Education Delivery System (NEEDS) of the NSF-SYSTHESIS Coalition. The mechatronics curriculum is developed on the following: (1) the fundamental principles of mechatronic technology; (2) the hands-on experience; and (3) the application of mechatronic technology to the industry in the region. Thus, this model will benefit universities and industries in other regions who seek to develop similar models. It is conceivable that institutions in the Michigan and Ohio area may intend to develop item (3) for the automotive industry. This curriculum development is a result of close cooperation with the mechatronic industry in the Silicon Valley. Support in planning, implementation and equipment donations have been received from major industries such as the Hewlett-Packard Company, the Storage Systems Division of IBM, Quantum Corporation and a major robot manufacturer, Adept Technology, Inc. The success of this project will result in major impacts on engineering education in this country, in particular mechanical engineering education. It will also make significant contributions to the manufacturing industry, especially those involved in high technologies.

New Engineering Statistics Course with a Virtual Computer Laboratory

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DUE-9455393
FY 1995 $ 100,600
Engineering

A new engineering statistics course with a virtual computer laboratory addresses the problem of offering a computer laboratory-based course in a university with large enrollments and few computer laboratories. The aim of this project is to design and implement an integrated classroom and laboratory experience for junior-level engineering students who can communicate with fellow classmates and instructors using electronic mail and file transfer software from their residence or place of work. Computer modem access is the only necessary student hardware. Statistical solutions to multidisciplinary engineering problems are created by student teams using statistical methods discussed over the university's existing communication network. The statistical laboratory materials being developed by various researchers are integrated into this virtual laboratory setting, thus making all results accessible to a larger audience. Classroom, laboratory, and course assessments, comparing this new course to a traditional engineering

statistics course, offer educators the opportunity to evaluate the validity of this integrated course for their technical course offerings.

Aerospace Concepts for Elementary Education Majors

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DUE-9455346
FY 1995 $ 120,000
Engineering

There is a critical need to improve the quality of science instruction in elementary school classrooms. This project addresses this need by having College of Engineering faculty offer a course for elementary education majors that focuses on current engineering topics and, more importantly, presents material in such a way that future teachers will be able to use the material in their classrooms. This is accomplished by first introducing the scientific principles of an engineering topic, then providing instruction in an appropriate teaching method, and finally completing the topic with a laboratory session that involves projects that can be used in an elementary classroom. The course is being developed by engineering and education faculty in collaboration with elementary school teachers. Each topic is being offered as a module to facilitate portability to the elementary classroom and to allow offering the course for either one, two, or three credit hours. Preservice elementary majors are being targeted although the course is suitable for inservice teachers and could be easily tailored to accommodate middle-school participants. The PIs are collaborating with College of Education faculty to overlap this course with their existing science teaching methods course. It is anticipated that participants will be more confident with science topics and, using this material, will be able to teach science more effectively. Dissemination of the developed materials will occur via presentation at professional meetings within the state and nationally. In addition, a textbook is being created to accompany the course. The effectiveness of the course will be evaluated by interviewing participants and College of Education faculty.

Washington State Manufacturing Technology Standards, Competencies and Curriculum Development

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DUE-9453739
FY 1994 $ 429,680
Engineering

South Seattle Community College, Boeing Company, Eldec Corporation, Clover Park Technical College and 12 other organizations are developing a process for determining specific workplace standards for manufacturing education and training in Washington State. These standards will, in turn, lead to an industry-guided manufacturing technology core curriculum. The curriculum will begin in high schools and will feed into a 2+2 Tech Prep post-secondary community college program. A workplace-based internship will also be an integral part of the

curriculum. This comprehensive, innovative project has strong support from both labor unions and industry. It will help bridge the gap between secondary school technical education and the requirements of the industrial workforce.

Development of an Interdisciplinary Curriculum in Electronic Materials and Devices: Cooking Without Recipes

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DUE-9551520
FY 1995 $ 224,000
Engineering (LLD)

An undergraduate engineer is expected to possess a wide variety of skills and knowledge beyond the fundamental engineering content of his or her course work. The need for improvement of student skills in communication, problem solving, integration of knowledge and teamwork is commonly understood. Some of this need can be met by a change in the techniques used in the teaching of laboratory courses. The traditional method of laboratory instruction frequently degenerates into a "cookbook" method, a mode in which students follow a "recipe" for experimentation from their lab book. Such exercises do not teach students to conduct an independent scientific experiment, or to record and communicate to others the information obtained during the course of an experiment. The "cookbook" method also fails to teach students to derive information explicitly from measured parameters or to properly apply statistics. In short, most laboratory instruction does not contribute to the development of the student as a critical thinker. One solution to this problem is to abandon the "cookbook" in favor of a sequence of team-oriented, open-ended laboratory experiences. In this mode of laboratory instruction, students are given a problem, trained to use the experimental apparatus, and taught the fundamental concepts necessary for understanding the problem. They are required to design the experiments and analyze the data without recourse to recipes. Since it is believed that these skills cannot be taught in a single course of instruction, the objective of this project is to develop independent exercises for introducing experimental design skills into two prerequisite classes on semiconductor devices and electronic properties (MatE 153 and EE 128), followed by an interdisciplinary, team-oriented design course in semiconductor process engineering (EE/MatE 129). The latter course will simulate the engineering roles of industry, where interdisciplinary teams are the rule, and open-ended experimentation is a fact of life.

Publishing Conference Proceedings on Mosaic

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DUE-9552585
FY 1995 $ 12,000
Engineering

The Institute of Electrical and Electronic Engineers' (IEEE) Education Society and Computer Society and the American Society for Engineering Education's (ASEE) Educational Research and Methods Division (ERM) are producing the proceedings of the 1995 Frontiers in

Education (FIE) Conference in electronic format for distribution via World Wide Web, CD-ROM and conventional computer disk. The FIE conference represents a major forum for dissemination of curricular innovations in engineering education, including many projects developed with NSF support. Additional co-sponsors in this activity include SONY Corporation, Purdue University, and the Illinois-Indiana Section of ASEE.

Course and Curriculum Development: Integrating Pre-Engineering Curriculum

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DUE-9455566
FY 1995 $ 75,000
Engineering

This project focuses on developing a year-long, team-taught pre-engineering program titled "Math and Physics: Tools for Careers in Engineering." The program emphasizes students working collaboratively to apply concepts taught in physics and mathematics to the kinds of problems encountered in the engineering profession. The planning and integration of an interactive physics and calculus laboratory into the curriculum is addressed.

By scheduling a daily three-hour block, the three faculty members in physics, calculus and engineering integrate their coursework in a two-quarter sequence which provides students with 10 credits in calculus, 5 in engineering physics and 9 in engineering problems, statics and circuits. The program is structured to accommodate students who need remediation in particular skills with learning assistance. It also is designed to create a classroom climate that promotes the pursuit of careers in science and engineering among women and underrepresented minorities.

To bring such a significant change to the curriculum, the three faculty investigators are devoting time to curriculum research during the first of the two-year project. They are consulting with two faculty experienced in developing an interdisciplinary program in science and engineering at the Evergreen State College, Olympia, WA; conferring with Professor Denny Davis at Washington State University, who developed a large-scale engineering curriculum project with DUE support; and visiting model interdisciplinary programs in science and engineering being developed at other institutions. In developing collaborative, small group approaches to instruction, they are guided by the expertise of the Washington Center for Improving the Quality of Undergraduate Education, a consortium of 42 colleges and universities that focus on learning communities as a means of reforming the undergraduate curriculum.

Dissemination of Results from NSF-Supported Engineering Education Projects

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DUE-9452911
FY 1995 $ 49,808
Engineering

The American Society for Engineering Education (ASEE) is publishing the results of NSF/DUE-sponsored research and innovation in engineering education in ASEE's *Journal of Engineering Education*, The Institute of Electrical and Electronics Engineers' (IEEE) journal, *Transactions on Education*, and other appropriate learned journals. In keeping with the scholarly

spirit of these journals, funding from NSF will assure valuable dissemination of the results of NSF-funded research. Thus, findings from NSF-funded research by principal investigators in the field of engineering education would be assured of the broadest possible dissemination in scholarly journals dedicated to expanding the body of knowledge that supports engineering educators nationwide.

An Advanced Undergraduate Laboratory for Microfabrication

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DUE-9551869
FY 1995 $ 217,273
Engineering (LLD)

This project is for the development of a laboratory-based undergraduate course in general microfabrication techniques and processes. Microfabrication was originally developed by the microelectronics industry to batch-fabricate miniature integrated circuits. Only recently has it been applied to other fields and disciplines. The slow infiltration of microfabrication technology into the non-electronic disciplines is due to the fact that microelectronic fabrication techniques have traditionally been taught only to graduate electrical engineering students or undergraduate students specifically studying microelectronic devices. In order for non-electronic interdisciplinary applications of microfabrication to be developed, an appropriate transfer of this technology to the interested audience needs to take place. The laboratory course being developed serves as that missing link by introducing this versatile and powerful technology to a broader audience base. Microfabrication can do for the mechanical and physical world what microelectronic fabrication did for the electronic world. The world of microfabrication has tremendous potential, and numerous applications to a wide spectrum of disciplines are possible. However, the majority of those applications will never be realized unless microfabrication is exposed to a broader audience and introduced earlier into the academic curriculum.

Development of a CD-ROM Based Multimedia Teaching Package for Introductory Materials Science and Engineering

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DUE-9455333
FY 1995 $ 100,000
FY 1996 $ 100,000
FY 1997 $ 93,000
Engineering

In a typical classroom environment, most of the time is spent in transferring information from a professor to a group of students, i.e., in a lecture format. In spite of the fact that it is well known that much more learning occurs when students are actively engaged in a discussion, as in the Socratic method, the lecture has been found necessary. This is because most students are either unable or disinclined to gain the "entry-level" information on their own from printed matter, in preparation for a tutorial type of classroom experience. This three-year program is

developing a CD-ROM-based multimedia package for the teaching of an introductory course in materials science and engineering. This package will serve most of the purposes of the lectures in a traditional course so that the classroom time can be devoted to the activities normally carried out in tutorial or recitation sessions. The motivation for this is the substantially higher teaching effectiveness of such sessions, compared to traditional lectures. The package is being built around animations created with Multimedia Director and ancillary programs and video segments showing excerpts from videotaped laboratory experiments created in a separate project, as well as videotaped lecture demonstrations. The techniques necessary for the creation of the animations and for computer-based editing of videotapes have been developed at the University during the past year, and the equipment and software necessary for this are already available. The first two years of the project are devoted mainly to creation of animations and video segments and to evaluating them by classroom use. As the materials are developed they are being used in the classroom and independently by students at the University and are being exported to other institutions via CD-ROM for their use and evaluation. The continuous feedback from this use is being factored into the ongoing creation of new material, so that final adjustments and modifications can be made during the period of the project. The teaching package is based on a new textbook, which is part of the development of a new approach to the subject. This is a departure from the traditional type of course in that it reorganizes the subject into two large case studies, one on structural materials, using the bicycle, and the other on device materials, using the Walkman. Experience has shown this to be more effective that the traditional method in an introductory course, especially for non-majors in materials science and engineering. It is anticipated that the development of this teaching package is enabling the subject to be taught in a variety of institutions currently not equipped to offer it in the traditional manner. In addition, this package should serve as a model for the development of similar packages for other subject areas.

Interactive Tutorial for Engineering Mathematics with Applications in Electrical and Computer Engineering

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DUE-9156103
FY 1992 $ 86,727
FY 1993 $ 88,154
FY 1995 $ 19,575
Engineering

This project develops and tests tutorial software which demonstrates basic topics of engineering mathematics necessary for entry level engineering courses. It also provides demonstrations of typical engineering applications. This tutorial software helps students understand and use these mathematical concepts in their engineering courses. The software is developed for terminals or workstations using XWindows and should be easily portable to many universities. The software is designed for low overhead use with no knowledge of programming languages, operating systems, or database structures required of the user. The first electrical circuits course is being used to evaluate the effectiveness of the tutorial software, and results of the evaluation will be used to improve the design and content of the system. The feasibility of using stored video recordings of real experiments for use with computer generated visualizations is being explored. The structure of the tutorial software is being documented so that others can add modules to the system. Distribution of the software will be handled by the Office of

Continuing Education at Santa Clara University and through Sun Microsystems' Catalyst Education Program.

Freshman Laboratory for Product and Process Engineering

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DUE-9550927
FY 1995 $ 200,000
Engineering (LLD)

A Product and Process Engineering Laboratory has been established for freshman engineering students. The purpose of the Laboratory is to bring students together in teams of three in order to explore fully-operative, familiar devices (e.g., videocamera, videocassette recorder, photocopier, bar code scanner) by playing the successive roles of user, assembler, and engineer analyst. The lab places emphasis on a "hands-on" approach to each device and on working in teams. Results from pilot offerings in Summer 1993 (12 students) and 1994 (18 students) indicate that this method creates an atmosphere in which students teach each other effectively, and in which women and minorities feel very comfortable and receive a positive and inclusive introduction to engineering. The objective of the project is the demonstration of a cost-efficient manpower design and scale-up of this novel freshman laboratory to handle a full cohort of up to 216 students per year for two years. Three 24-student sections/semester are offered in 1995-96 and five sections/semester in 1996-97. The method of laboratory execution involves roles for students, undergraduate and graduate teaching assistants, and the faculty director. The students, working in teams of three, examine each of six devices or processes. The senior undergraduates provide lab assistance and are selected so that they serve as role models for women and minority freshmen. The graduate teaching assistant (one per section) has general instruction and lab maintenance responsibilities for each section, and serves as back-up technical consultant to the seniors. The faculty leader provides an initial week of hands-on training of seniors and graduate assistants with the lab devices prior to each semester, leads the student discussion sections on outside readings, and maintains oversight of the laboratory operations. The project is significant because it provides an immediate "hands-on" introduction to engineering to freshman students in a manner which includes teamwork, oral communication and presentation skills, and is conducive to the recruitment and retention of underrepresented groups.

1995 National Engineering Faculty Forum: An Interactive Teleconference Series to Share Best Practices in Undergraduate Engineering Education

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DUE-9550462
FY 1995 $ 117,000
Engineering

Sharing and communicating the "best practices" in undergraduate engineering education is the goal of the project. Undergraduate college engineering educators are the targeted audience. College educators sometimes operate and teach in relative isolation, interacting with

each other once or twice a year and usually on a research topic rather than educational practices. This project addresses the need for engineering educators to interact specifically to gain the tools and techniques necessary to provide the engineering student the highest teaching standards available, no matter where the educational institution is located. Each telecast features an innovative "best practice" that can be adapted by a participant. The extensive experience and facilities of the National Technological University (NTU) are being applied to this project. Virtually all of the 11 years of NTU's history has focused on providing for the graduate and continuing education needs of today's busy engineers, scientists and managers.

The Division of Undergraduate Education (DUE) staff is working with the NTU staff to identify topics and presenters. Key teachers from the NTU network and nationally recognized experts and educators are being invited to present. Dr. Lionel V. Baldwin, President of NTU and Project Director, review the potential topics and speakers and consult with the DUE staff to make final decisions. The result is a plan for eight one-hour interactive telecasts offered on the third Tuesday of each month, starting in March, 1995, scheduled from 4-5pm ET. The telecasts are delivered on both C-band analog and Ku-band compressed digital video. This dual method allows for the most successful receiving options nationwide.

Each registered site receives a set of reproducible notes with references for more in-depth study when appropriate.

Several new marketing initiatives are being implemented. In addition to direct mailings, advertisements are placed in appropriate magazines and the series is described in the NTU Internet server on Gopher and the World Wide Web.

NTU considers the quality of the experience as evaluated by the participants a critical benchmark. NTU is developing the evaluation form using a faculty focus group to assure relevance and simplicity. NTU provides summary data after each telecast and a final report.

Curriculum Development - Manufacturing Systems

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DUE-9455764
FY 1995 $ 169,585
Engineering

This project is Phase II of a two-phase project to develop a two-course sequence in Manufacturing Systems. The sequence is serving as a model for manufacturing systems nationally. The project involves the New Jersey Institute of Technology (NJIT) as the lead institution for the North/Central Educational Technology Educational Consortium and Camden County College as lead institution for the Southern CIM Technology Consortium. The consortia operate fully articulated programs aimed at the AAS and BSET degree in Manufacturing Engineering Technology. The consortia involve all community colleges in New Jersey, thirteen in the Northern Consortium and six in the Southern Consortium. Articulated curricula of the two consortia include a two-course sequence in Manufacturing Systems. The sequence is critical to the success of the program. Significant deviations in course content and emphasis amongst the consortial colleges have been noted. This project involves faculty from the consortial colleges in development of model curricula and training modules for the Manufacturing Systems sequence. It also identifies possibilities for sharing of laboratory resources in support of the model. The first phase of the project, which involved soliciting input from the manufacturing sector on

required skills which should be attained from the sequence, is complete. It also involved the development of the model curricula and training modules for the first course in the sequence, Manufacturing Systems I (Introduction to Manufacturing Systems). Draft copies of the first modules have been distributed to consortial colleges and were also distributed at the NSF Project IMPACT Conference held in June 1994 in Washington, DC. The second phase of the project involves the development of model curricula and training modules for the second course in the sequence, Manufacturing System II (Advanced Manufacturing Systems). It also involves identification of laboratory resources throughout the consortia and procedures for arranging use in support of the model. Pre-publication editing, printing, and distribution of the final products are also included in this second phase.

Multimedia in Manufacturing Education—MIME

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DUE-9453883
FY 1994 $ 599,603
Engineering

Traditional classroom-based engineering education is often inadequate in preparing students for the complete process of manufacturing—the cycle of design, engineering, production, marketing, and delivery of goods. Some shortcomings include: restricted access to manufacturing experts because of the high cost of bringing them to the classroom; curriculum demands that do not permit the inclusion of rapidly emerging issues of vital importance to manufacturing; and few opportunities to experience or participate in an actual manufacturing process while in school.

MIME addresses these shortcomings through rapid development and deployment of a technology-enabled curriculum. Advanced media technologies are being exploited to create virtual, time shifted, and/or remote visits to real-world manufacturing systems. These efforts are based on the belief that learning is a constructive process in which the learner builds a personal representation of the world around him or her. The project uses technology to create greater opportunities for students to experience the real context of manufacturing systems and thus encourages the transfer and connection of classroom-based instruction to the real world.

The project is centered on three main activities: (1) creation of a manufacturing-focused multimedia development resource; (2) rapid infusion of educational technology into the manufacturing curriculum; and (3) production and dissemination of interactive courseware. Industry will be actively involved in all phases of the project through existing partnerships at the Georgia Institute of Technology. Initially, MIME is targeting students returning to Georgia Tech to pursue a new degree program in product realization. The PI's intent is to produce materials which can be easily adapted to needs of industry as well.

Detailed classroom experimentation and revision are used to evaluate the learning and cost effectiveness of the materials. MIME represents one of the first attempts to apply interactive educational technology across a complete multidisciplinary engineering curriculum. Since the project focuses entirely on software-based learning modules, all materials generated can be made available for public use via the Internet. The final products also will be distributed through existing publishing channels. Finally, results will be shared through technical conferences and appropriate publications.

SILICON RUN I.2 - An Educational Film on the Manufacturing Process of Integrated Circuits for Undergraduate and Adult Education

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DUE-9455761
FY 1995 $ 50,000
Engineering

Integrated circuits and the computers they drive are an integral part of modern electronics. The continuous introduction of faster, more powerful computers is increasing the demand for a highly skilled workforce and an educated public. Increasing an understanding of manufacturing in the semiconductor and computer industry is an educational challenge, which is greatly enhanced by the use of visual images. Field trips to manufacturing sites are, unfortunately, not available to students and educators outside of industrial regions. When tours are possible, industry's clean room restrictions allow viewing only from a distance and through glass windows.

The SILICON RUN two-part film series takes its viewers through these windows and allows them to visually experience the beauty and ingenuity of manufacturing. Step by step, using live footage, closeups, animation, and special effects, the two films provide a clear overview of complex processes in semiconductor and computer manufacturing. SILICON RUN I, produced in 1986, explores crystal growth through IC wafer fabrication. SILICON RUN II, produced in 1993, continues with testing and packaging, through system assembly.

The new production, SILICON RUN I.2, updates the first film of the series so it reflects the technological changes of the past decade. With non-profit sponsorship from the Film Arts Foundation and the collaboration of Stanford University's Electrical Engineering Department, the goal is to re-film the industrial manufacturing footage so the series can continue providing viable information about today's manufacturing.

The series is used for education and training—thousands of students in universities, colleges, technical schools and industrial training programs view these films every year. SILICON RUN I.2 will be disseminated to its present users, which include the membership of the National Electrical Engineering Department Head Association. Dissemination goals are to distribute to the following departments: Electrical and Computer Engineering, Manufacturing Engineering, Engineering Technology, Electronics Technology, Industrial Technology, Computer Technology, Computer Science, and Physics and Science Departments.

Hands-On Engineering Homework: A New Approach to Out-of Class Learning

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DUE-9455705
FY 1995 $ 95,796
Engineering

This project pioneers a new way to provide experimental complements to theoretical courses. The goal is to train students to use what they learn to examine all that they see and as a result, to question. The fundamental idea is to create a suite of simple experiments which can be done in the home and assigned like homework problems. Such simple, but elegant experiments,

are dubbed Hands-On-Homework (HOH) which encourages students to use engineering theory to explain everyday phenomena, and to compare their observations to theoretical prediction; provides open-ended opportunities to explore engineering questions using readily available materials and familiar experiences; trains students to conduct "reality checks" and naturally apply theoretical analysis to experimental observations; and provides continuous opportunities for students to empirically explore engineering questions throughout their college careers and develop habits contributing to life-long learning. This project is tied to curriculum changes planned for the new Integrated Teaching Laboratory. Hands-On-Homework is liberally sprinkled throughout the entire curriculum, primarily in the first three years, including introductory mathematics and physics courses. Initial disciplinary courses such as statics, dynamics, thermodynamics, and circuits benefit, as well as more advanced courses such as fluid mechanics, heat transfer, control theory, or materials. HOH problems are piloted in two courses while doing an outreach to identify further courses. Evaluation is done by holding consensus groups during the semester and comparing performance of students with and without HOH. Results will be presented at meetings and reviews. Ultimately, a user's guide will be produced containing all the Hands-On-Homeworks as well as the performance evaluations. Because HOHs are low-cost, they can be easily replicated and the results of the project widely exported.

An Innovative Course on Elements of Manufacturing Systems for Non-Engineering Students

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DUE-9455748
FY 1995 $ 124,286
Engineering

This project involves the design, development, and implementation of an introductory course on manufacturing systems for non-engineering students. In this project, innovative teaching and learning styles suitable for teaching manufacturing concepts are identified and incorporated in the course to motivate students to learn, understand, and appreciate the role of manufacturing in today's society, its impact on the economy, and its career potential. This course builds on the background and skills of first- and second-year university students, to give them a better understanding of the value of basic courses in mathematics, physics, and chemistry, in learning engineering concepts. It also introduces non-engineering students, especially women and underrepresented minorities, to manufacturing in a non-intimidating manner. It is hoped that this exposure will strengthen their confidence, dispel their fear of technology, and motivate them to choose an engineering career.

A preliminary study conducted through pilot sections of the course offered at Northern Illinois University during Spring and Fall 1994 to assess the need for this course and its potential benefits resulted in positive outcomes and gave the impetus for developing this course fully. The project methodology involves the identification of manufacturing life cycle concepts suitable for this course and its target audience, and the design and development of course activities, lesson plans, laboratory experiments, and instructional aids that accommodate different teaching and learning styles so that the course material can be conveyed effectively to a non-engineering student population. The progress of the project is evaluated by a team consisting of members from academia, including the Director of Diversity for the College of Engineering and

Engineering Technology at Northern Illinois University and faculty from education, physics, and curriculum and instruction, and the manufacturing industry.

The course material developed for this project, the teaching and learning techniques that are used in conveying the material to students, and the results of the study are of great value to educators everywhere interested in offering similar courses to non-engineering students. The developed course gives students the motivation and the reason for learning basic mathematics and science topics and dispels their fear of science and engineering courses. The emphasis placed on teaching and learning styles also helps students to understand their own preferred learning styles and improve their performance. This course also serves as a vehicle for non-engineering students to experience and explore what engineering has to offer without actually joining an engineering program and see for themselves if they can be successful in an engineering career.

Multimedia for a "Hands-On" Oceanography Course

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DUE-9455758
FY 1995 $ 85,078
Geosciences

The purpose of this project is to continue to develop software for a series of "hands-on" multimedia lab modules intended for a lower division oceanography course with a "Quantitative Science" component. The emphasis is on individual and group discovery, observation and analysis of the most current geophysical and geographical data, and the communication and revision of ideas through both group discussions and writing. Some of the tools being developed for this project provide access to data that has been previously accessible only to graduate students specializing in a field related to that data. The development includes a student laboratory manual, a CD-ROM, and an instructor's manual. The home page (http://oceanography.geol.ucsb.edu) contains availability information. The focus of the software and supporting lab manual is to guide students through the process of making observations and writing a technical paper that describes their results and interpretations. This process takes place over a period of four weeks. The datasets available are (1) global elevation; (2) global volcano distribution; (3) global earthquakes; and (4) images and movies of areas of geological interest, such as movies of seafloor dives in Alvin. Students access these data by simply pointing and clicking. Extensive support is provided to help students visualize the features they are studying. A profile game has been created to help them learn to use the software tools to determine the shape and physical properties of structures they observe in the elevation database. This game is being modified, as it was too difficult for many students during tests. Supporting student writing is a key component of this project; many students do not know how to write in a technical style. The profile game is being enhanced to produce sample descriptions of the (randomly generated) feature the student is studying. A database of sample writing is being implemented also. Some students have difficulty determining how earthquake data, topography data, and volcano locations are combined to determine the type of plate boundary. Several "discovery" problems, focusing on small regions, are being created to help them develop this skill. The current writing software supports random anonymous peer review. Students send their writing to review, review others' writing, and revise and modify their own writing. Students are highly motivated by having access to their scores. Many of the homework assignments are entered into the computer and graded immediately. All grades are entered into a central database, where they are accessible to all TAs, the professor, and the student (his/her grades only). Testing has been done on a number of small groups (Spring 1994), two class sections (Fall 1994), and the entire class (Winter 1995). Most of the students in the Spring and Fall tests praised the "hands-on" aspects and freedom to explore. Some were over-challenged by the open-ended nature of the work. The Winter 1995 test implemented the automatically graded homework entry for the first time. Students were critical of initial bugs in the homework entry software and the difficulty of the profile game. However, most students worked at the homework until they got 100%, and their written papers were quite good. During review sessions, students were noticeably more proficient at answering questions about earth processes. Evaluation is being done using both written student feedback and in televised focus groups.

New Geology Laboratories: Interactive Data Acquisition, Analysis, and Multimedia Modules of Geologic Phenomena, Part II

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DUE-9455300
FY 1995 $ 75,000
Geosciences

This project brings an individualized approach to science in large introductory courses for non-science and science majors through participatory geoscience laboratories. Use of the multimedia products developed to date show that this new approach produces excitement and increased comprehension. Field and laboratory data acquisition, statistical analysis, and computer modeling of complex systems, are elements throughout. The laboratories develop skills such as field and laboratory data gathering, graphical analysis, statistics of data, mathematical representation of results, map representation of information, computer modeling, synthesis and simulation of complex phenomena, and the interaction of science and society. The topics of the laboratories in this project include earthquakes, mass wasting, topography, surface water chemistry, and earth resources and materials. The end products of the development will be a CD-ROM and a paper laboratory manual. The multimedia components in SuperCard can be used for instruction. These modules contain extensive visual material of geologic phenomena, interactive computer models of significant physical principles, video and audio segments of geologic processes and simulation models of complex geologic problems.

Development of a Dynamic Digital Map Template for Desktop Computer Users to Insert Digital Maps and Data to Generate High-Quality Color Maps for Digital Publication

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DUE-9455563
FY 1995 $ 70,000
Geosciences

Part of the problem in field-related geologic research is the inability of workers to publish high-quality color geologic maps quickly, inexpensively, and in a format that is widely usable without additional software, or software that requires extensive training to use. This is especially true of maps with large geographically tied databases. This project is creating a Dynamic Digital Map (DDM) Template into which users of SuperCard can insert their digital maps to generate their own high-quality color geologic maps for publication in computer format. This template has similar, but more generalized capabilities, to those described by Condit (1995, *GSA Today*, v. 4, p. 86) in his description of DDM.SVF. The Template includes all essential objects (windows, cards, menus, data fields and text buttons) with associated script that link these objects to the maps, data fields and text files. Data that can be inserted include maps, digital images, chemical, paleomagnetic and structural data and text files. The initial

development platform is the Macintosh computer; the pending development of a DOS version of SuperCard may allow conversion of projects to a DOS Windows format. Concomitant with development of the Template, the project is developing a tutorial manual to include: (1) a brief introduction to the use of SuperCard as it pertains to making Dynamic Digital Maps; (2) an overview on the structure of the template program; (3) a step-by-step description of how to load the Template into SuperCard, and insert maps, images and data and text; (4) how to copy and attach script that links objects pasted into the Template; (5) how to most efficiently duplicate and rename essential objects of different classes to facilitate the user's own map DDM generation; (6) how to modify given objects (e.g., windows, data fields) to conform with slightly different user needs; and (7) how to turn the user's SuperCard DDM into a stand-alone program for distribution in a form which can be run independently of SuperCard by any end-user. The over-riding consideration guiding the creation of the Template and tutorial is to make it as efficient as possible for the user to make DDMs. Initial distribution of review versions of the Template and tutorial will be by Internet (FTP); an early version of the tutorial can be obtained by anonymous FTP from 128.119.45.20 in the directory ccondit. Final publication should be on CD-ROM. It is hoped this type of publication will be of interest to professionals and students alike.

Educational Earthquake Visualization

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DUE-9455417
FY 1995 $ 138,133
Geosciences

Despite the important role that earthquakes and seismology play in the Earth Sciences, there has been up until now no good way to visualize the process by which an earthquake generates waves that propagate throughout the Earth. These seismic waves are important because they cause destruction in many parts of the world, are used to determine the location and size of the earthquakes, and are the means by which geologists have mapped out the interior of the Earth. Without a way to visualize the process of seismic waves spreading throughout the Earth after an earthquake, it has been very hard to explain this phenomenon and for students to understand it. The difficulty lies in the fact that the production of such an animation requires advanced geophysical algorithms, high-speed computational capabilities, and a strong dedication to use these research capabilities for an educational purpose.

This project meets this need by producing a computer-graphics color animation that accurately represents the propagation of seismic waves from an earthquake, and is available to educators in both VHS-video and computer formats. The project is based on a prototype of such a video-animation recently made by the PI. The production of a realistic visualization of earthquake wave propagation through the Earth is computationally intensive. The prototype took five months of computation on a Sun Sparcstation 10/41. The animation not only gives viewers an intuitive feel for the internal structure and layering of our planet, but also teaches the principle of wave physics applied to the Earth, showing waves reflecting, refracting, and diffracting along the different layers within our planet. The computer animation is narrated, presenting an educational discussion of earthquakes, their destructive capabilities, their relation to plate tectonics, and their role in mapping the details of the interior of the Earth.

Computer-Aided Learning Modules for General Education Geology Courses

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DUE-9455542
FY 1995 $ 247,110
Geosciences

This project takes advantage of recent developments in multimedia computer technology to create an integrated set of computer-aided learning (CAL) modules to teach fundamental concepts of geology in general education courses. The software consists of graphics-intensive, interactive multimedia modules that include animation, video, sound, and hypertext linking across topics. Module topics include global geology, plate tectonics, geologic time, Earth interior, Earth materials, global cycles, human influences, and evolution of the Earth. Questions throughout the material provide immediate feedback to the students and guide their progress. Quizzes after each section assess concept attainment and provide automated scoring for assessment of student progress and effectiveness of the instructional media. The new modules build on the success of an award-winning pilot module developed by the PI, and are guided by student evaluations collected throughout the development and assessment phases. The initial target audience is students in two large general education courses for non-science majors (>60% freshmen-sophomores, ~10% education majors) taught by the PI (History of Life) and the Co-PI (Planet Earth). The modules have broad applicability to any introductory geology general education course, and will be published, widely advertised, and disseminated nationally to universities, colleges, junior colleges, and high schools. Extensive use of the modules in the preparation of elementary and secondary teachers is planned.

The Unity of Science: A Year-Long, Exploration-Oriented Interdisciplinary Science Course

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DUE-9455682
FY 1995 $ 150,000
Interdisciplinary

The goal of this course is to develop an interdisciplinary introductory science course for first-year college students that emphasizes the methods and relevance of scientific inquiry. Target students are primarily those students that do not intend to major in a science. The course content includes interdisciplinary topics of broad interest in logical sequences. It begins, for example, with color vision (physiology, perception, optics, spectroscopy), autumn foliage (isolation of chlorophyll, photosynthesis, light as energy), and the origin of oxygen-rich atmosphere (respiration, flow of energy through biosphere, ecosystems). This theme (light, energy, and matter) then leads the students through topics in astronomy, physics, chemistry, geology, and biology, all in context and without traditional discipline boundaries. Laboratory demonstrations and exercises are exploration-driven with students actively participating in defining the questions that are asked and how we look for answers. In the last half of the year, small groups of students carry out self-directed research projects and present their results to the class. Three faculty from different disciplines are teaching the course through lectures to the entire class (approximately one-third of the meetings) and in smaller discussion groups (two-thirds of the meetings). Course content is able to evolve and change depending on the faculty involved in a given year. A lab director facilitates weekly lab exercises, and senior students from all disciplines serve as teaching assistants and role models. Students are graded by the quality of exploration reports, projects, and personal journals. There are no timed exams.

Linguistic Semantics as Science

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DUE-9150417
FY 1991 $ 74,002
FY 1992 $ 115,728
FY 1993 $ 32,667
FY 1995 $ 15, 025
Interdisciplinary

The goal of this project is to create a sophomore-level undergraduate course introducing students from a wide variety of backgrounds to the principles and results of linguistic semantics. The heart of this course is a software "workbook" that presents the material in an interactive, graphic environment. The course and workbook address various aspects of meaning, including its relation to word and sentence form (morphology and syntax), its relation to systems of mental representation (cognition), and the interaction between meaning and use. The goals of the course are to reveal to students the complex internal system of rules and principles that underlie our abilities as native language speakers to let them experience some of the intellectual excitement

that comes with discovering such principles and struggling to formulate them in a precise way, and to encourage them to explore the computer as a model of how we, as human beings, think and understand. The results of this work are of significant value in introducing undergraduates to the principles of scientific reasoning, in reaching students not otherwise considering science majors or extensive science electives, and in helping to foster interest and interdisciplinary exploration in the cognitive sciences.

Visualization Technologies in Environmental Curricula (VTEC)

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DUE-9354599
FY 1994 $ 246,980
FY 1995 $ 153,411
Interdisciplinary

The Visualization Technologies in Environmental Curricula (VTEC) Project is a large-scale partnership effort among: Sigma Xi, the Scientific Research Society; North Carolina State University; Duke University; the University of North Carolina at Chapel Hill; The North Carolina Supercomputing Center; North Carolina Central University; The North Carolina System of Community Colleges; industry; government; faculty; and student consultants. VTEC is a two-year project to develop, demonstrate, and evaluate an interdisciplinary, problem-oriented, team-based, environmental case study development strategy involving faculty, undergraduate students, and consultants from industry, government, and supercomputing centers. The project employs environmental curriculum case studies and instructional materials that effectively integrate the power of computer networking and visualization technology in enhancing understanding of scientific concepts and their interrelationship with other disciplines in the solution of complex environmental issues. These visualization-enhanced case studies are intended to increase environmental and scientific literacy and improve undergraduate student attitudes toward science and technology careers, particularly among women and underrepresented minorities. Comprehensive, project-driven computer visualization and networking skills development at the North Carolina Supercomputing Center enable excellence in curriculum development for collaborators from participating universities and community colleges.

A New Approach to Earth and Environmental Science Undergraduate Instruction

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DUE-9455688
FY 1995 $ 150,000
Interdisciplinary

Columbia's Department of Geological Sciences and Barnard's Department of Environmental Science are developing a new curriculum in Earth and Environmental Science that builds on the intellectual and information resources of Columbia, Barnard, Teachers College, Lamont-Doherty Earth Observatory and the NASA/Goddard Institute for Space Studies

(GISS). This two-year project involves design of a multidisciplinary introductory core curriculum, for both geology and environmental science majors. This three semester core, serving both Barnard and Columbia, focuses on three interacting global systems: the lithosphere, the climate system, and the biosphere. Women form a key target audience of this enhanced curriculum, through merging of the Barnard introductory sequence with that of Columbia. The core incorporates new technologies for accessing, analyzing and transmitting information, thus shortening the information path between research scientist and undergraduate. An electronic library containing data, text, models, graphics and analytical tools is being developed. Through this electronic library, students can explore features of the three systems and processes that operate within and among them. The design team, brought together from within the Columbia community to develop and implement the curricular revisions, engages a wide variety of scientists and educators in the process.

Discovery - Based CAI Fundamentals of Science Course Focused on Relationship Thinking, History of Science, and Math Applications

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DUE-9455599
FY 1995 $ 132,905
Interdisciplinary

The project being developed is meeting a demonstrated need to provide an interesting, challenging, entry-level science course in community colleges to improve the success rates of educationally-disadvantaged students. Many students are under-prepared for mastering concepts in college-level biological and physical sciences because they do not understand principles which use relationship thinking. The objective is to develop an interdisciplinary, experiment-based FUNdamentals of Science course with a history-of-science theme and discovery methods to investigate measurement, density, gas laws, electric circuits, and light, including lasers. Relationship thinking and skills to use mathematics as a tool are being developed by having students use a computer program to create graphs of relationships from data. The program targets the many new and returning students who function at approximately the intermediate algebra level. This group includes especially women, African-Americans, and Hispanics who need a successful experience in their introduction to the sciences. Three four-year college professionals in undergraduate science education have agreed to serve as advisors for this project. Student progress is being tracked and analyzed. Detailed explanations for integrating experiments and computers into the entry-level course are being developed and disseminated. A workshop (Innovations in Science Teaching) to present the methodology and materials developed will be scheduled for science teachers, including teachers from area secondary schools.

Integrated Science for Elementary School Teachers: A Course and Practicum Approach to Restructuring Undergraduate Science Preparation for Teachers

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DUE-9254158
FY 1993 $ 207,597
FY 1994 $ 179,427
FY 1995 $ 124,797
Interdisciplinary

This project is developing and implementing a two-semester course of instruction designed to provide an integrated introduction to science for preservice elementary education (first through eighth grade) majors. Concurrent with an inquiry-centered, laboratory-based content course is the development of a practicum in which the preservice students work with master teachers/mentors to translate science content into actual learning situations for children. This practicum involves teachers and students from the Moscow, Idaho Public Schools, and the Coeur d'Alene Reservation Schools. Additional school districts are being brought into participation as the project matures. At the end of three years, all elementary education majors will be participating in this program. The curriculum is being developed by six research faculty from the departments of chemistry, biology, physics, geology, and biochemistry, in collaboration with science education specialists as well as teachers and administrators from regional schools. The courses present science as a seamless whole through a blending of discovery-based activities and cooperative learning in a technology-rich environment. While this is a content curriculum, it presents science in ways that model the best teaching practices.

Basics for Technicians: An Integrated Course of Study Encompassing Mathematics, Chemistry, and Physics

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DUE-9254184
FY 1993 $ 115,000
FY 1995 $ 25,145
Interdisciplinary

Building on experience in programs to upgrade the educational background of personnel working in industry, Dutchess Community College is developing an integrated curriculum which could become a certificate program in basics for industrial technicians. A faculty team is developing a single, unified course integrating elements from what are currently separate courses in introductory mathematics, chemistry, physics, English and reading. Modern manufacturing is being used as the integrating theme. The project will significantly change the undergraduate learning experience through the employment of new curricula, innovative laboratories, new delivery systems, and fresh instructional materials. It is hoped that the project will be a blueprint for the development of an industrial technology certificate granting program which could be replicated by other institutions of higher education, particularly technical colleges.

Portfolios to Integrate Mathematics, Science, and Computer Science

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DUE-9455559
FY 1995 $294,797
Interdisciplinary

This project is based on the College's successful NSF collaborative computer calculus project in which students create a product in collaborative groups. These products include calculus movies and portfolios, that can be shown to a prospective college admissions committee or employer. A portfolio requires students to make a careful selection, based on evaluation and insight into the process of their education. The program has improved success and retention for women and minorities in calculus. The current project is creating an educational environment that emphasizes the interconnection of all fields of scientific knowledge in order to prepare students more effectively for the scientific environment of the future. This project is improving on the past project by using the portfolio product mode in physics, chemistry and computer science courses, and by adding physics and chemistry and computer science projects throughout the calculus sequence, and to courses in precalculus, discrete mathematics, and differential equations. The results of this project were disseminated to 50 college mathematics and science faculty members through the mathematics department's NSF Undergraduate Faculty Enhancement workshops in the summer of 1995 at BMCC. In addition, the senior faculty of the project publish, read papers and give workshops at MAA, NCTM and other regional, national and international conferences. The impact of this project is the creation of a more diverse and richer scientific environment to strengthen the bases of the mathematics, science, and computer science educational program, computers and collaborative learning.

Building Environmental Literacy Through Participation in GIS and Multimedia Assisted Field Research

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DUE-9552283
FY 1995 $ 300,000
Interdisciplinary (LLD)

Three related laboratory exercises to support the undergraduate environmental literacy initiative at the University of Georgia are being developed, evaluated, and implemented. This collaborative effort involves the Departments of Geography and Instructional Technology, the Institute of Ecology, and the State Botanical Garden. Students are becoming active participants in long-term ecological studies that require them to test formal hypotheses based on data they collect in the field. They are being assisted by a computerized geographic information system (GIS) as they analyze and interpret results. An interactive multimedia program, which incorporates a performance support system, is guiding them through the field research and data analysis. The following goals are addressed by the project: (1) instruct students from a broad diversity of backgrounds and interests in fundamental scientific concepts including the design and testing of hypotheses; (2) demonstrate the importance of spatial and temporal variation in the

study and understanding of natural systems; (3) strengthen geography skills and familiarize students with the purpose and use of computerized geographic information systems; and (4) create interest in scientific research and science education as career opportunities. The immediate audience is the undergraduate student population of the University, where completion of an environmental literacy course is a requirement for graduation. The project will be disseminated as a model that can be adapted for use at other institutions to increase environmental literacy and expose undergraduates, including future teachers, to new technologies that enhance the study and teaching of science.

Development of an Integrated, Multidisciplinary Science Literacy Course for Comprehensive Universities

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DUE-9455440
FY 1995 $ 101,620
Interdisciplinary

Recent reports on the state of science education have identified a need for more process-oriented, multidisciplinary science courses; these reports also call for science courses that are integrated within a coherent general education program. This project involves the development of a two semester laboratory-based introductory science course taught collaboratively by faculty members from different science disciplines. Specific objectives of the project include (1) the development of a multidisciplinary introductory science course for large, comprehensive universities; (2) development of methods to link introductory science courses with other courses in the humanities and the social sciences; and (3) investigation of problems associated with collaborative teaching approaches to multidisciplinary science courses.

A multidisciplinary science course, called the Natural World, is being developed by a team of ten faculty from six science disciplines. The course is modular in nature and centers around multidisciplinary topics of current relevance. The Natural World emphasizes the basic foundations of natural science, science as a way of knowing, the uses of science, historical influences on the development of science, and the interrelationships between science and culture. A unique aspect of the Natural World is its integration within a new core curriculum of 38 hours that integrates the various academic disciplines within a set of comprehensive and cohesive interdisciplinary courses. Evaluation of the project includes student and faculty surveys, nationally normed instruments, student portfolios, oral exit interviews, and outside reviewers.

Products being developed as a part of the project are approximately ten modules of multidisciplinary topics that can be used in introductory science courses. Each module includes an instructor's guide, a student guide, suggestions for student and teacher readings, writing assignments, student handouts, and laboratory exercises that involve collaborative and discovery-based learning. A second product being developed is a manual on collaborative teaching for interdisciplinary courses. A third product is information about specific methods for developing connections between science courses and courses in the humanities. Products and project results are being disseminated in written and electronic form and through presentations at national meetings and peer-reviewed papers in scientific journals.

Student-Active Science: Models of Innovation in College Science Teaching

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DUE-9552886
FY 1995 $ 26,998
Interdisciplinary

Traditional lecture-based courses often lead to lack of student engagement and learning. To improve student learning, faculty from across the country are experimenting with more active, inquiry-based approaches to teaching science. This conference will bring together faculty from various disciplines and diverse institutions to document their success. The conference will be held at Hampshire College in June 1996 and will be attended by about 30 faculty and administrators from 10-15 colleges and universities. The attendees will contribute essays detailing both the specific examples of innovative and effective approaches to classroom and laboratory teaching, and the institutional dynamics necessary to make and keep these innovations. From the interactions at the conference, authors will include ideas and criticisms, comparisons among institutions, and a synthesis of the best of the ideas. These papers and commentary will be published in the conference proceedings.

The UCLA Science Challenge

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DUE-9455570
FY 1995 $ 149,999
Interdisciplinary

The UCLA Science Challenge began in 1991 as a five-year program with a mission to bring innovative, research-level instruction to undergraduates, particularly lower-division students in order to retain lower-division science majors, recruit new science majors, attract more minority students to science, and improve student attitudes toward science. The goal is to infuse every lower division course in the physical sciences with new material and to create new interdisciplinary courses that reflect the breadth and overlap of the physical and life science disciplines. As the fourth year of the program begins, it is on target to meet its charge. During the first half of the project, participation includes both the largest general education classes in the division, the astronomy and atmospheric science courses, which collectively enroll 8,000 non-science majors each year, and also courses for the physical science majors in chemistry and physics. The major focus now is on the physics course for life science majors. The minor focus, for the enormous general chemistry course that all life science and physical science majors must take, is concentrated on modules that allow students to visualize three-dimensional molecular and crystalline structures. A small presence is being kept in the Earth and space science department, in astronomy, and in atmospheric science in order to maintain the coherence of the renovation of the physical sciences at UCLA and to fulfill a commitment to complete the modules which these departments have begun.

Fundamentals of Natural Science for Non-Science Students: An Integrated Approach

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DUE-9455413
FY 1995 $ 100,000
Interdisciplinary

A new, integrated course in natural sciences is being developed for non-science majors. This course, Fundamentals of Natural Science (FNS), is the cornerstone for a two-tier, interdisciplinary curriculum in the natural sciences and differs from traditional science offerings in both content and delivery. FNS is being designed to build a foundation for scientific literacy, develop habits of mind consonant with critical thinking, and give students the sense of discovery and accomplishment that comes from "doing science." Because contemporary students have a keen interest in their environment, examples from the natural environment are being selected to illustrate the basic concepts of science under consideration. The examples are being explored in a set of learning exercises designed specifically to promote active inquiry and cooperative learning. These exercises are being developed by faculty and teaching assistants with guidance from the University of South Florida Center for Teaching Enhancement. Textbook and exercise manuals are being developed.

Modeling Applications in Environmental Management: Preparation of Text and Teaching Guide

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DUE-9455719
FY 1995 $ 100,000
Interdisciplinary

This project is designed to meet a need for well-prepared, modular course materials based on a new, innovative course on mathematical methods in environmental management, one that is adaptable to various educational frameworks. These materials have dual objectives: to teach students about the complex range of everyday environmental issues that are faced by business and governmental organizations, and to give the students first-hand experience in the key role that quantitative modeling plays in dealing with these issues. The present course has a significant field component that includes visits to operating companies and government installations. The purpose of this project is to develop textbook materials and teaching guidance that would enable a wide range of teachers primarily at the college level, but also at the high school level, to incorporate some or all of the same material in offerings at their own institutions.

The subject areas addressed include air pollution, surface water, groundwater, hazardous materials incidents, risk analysis, and public health. Computer analysis is key to many of the activities, ranging from calculation-type programs, often set up in spreadsheets, to information searches on the Internet. In addition, communications skills are emphasized, such as organizing

a complex problem description, formulating a solution strategy, and presenting a convincing analysis to others.

During the development process, modules are to be class tested by both the PI and other Bentley teachers, and the material will also be made available to other institutions both in printed form and electronically. The participation of a three-person Advisory Board containing experienced representatives from a range of institutional types facilitates the targeting of other volunteer test sites. Therefore, in addition to the preparation of the teaching guide, a special teacher training program is also part of the project.

Integrating the Electronic Desktop into the Natural Science Curriculum

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DUE-9455428
FY 1995 $ 200,000
Interdisciplinary

This project's strategy is to use the power of advanced workstation technology to improve the way science is taught and learned in a multicultural university. Project activities have four faculty persons from biology, chemistry and the earth sciences collaborating to develop three new interdisciplinary courses, write 29 interactive science visualization courseware applications, revise instructional delivery, prepare a variety of instructional materials that can be used at other institutions, integrate Internet resources into the classroom, and create a new class of instructional applications that can be executed remotely over the Internet using the World Wide Web protocol. This project involves, each year, about 200 students who are science majors and 500 general education students. The goals are to increase retention of majors and the scientific literacy of non-majors. Courses are offered in a highly visual, user-friendly, computer-based learning environment that is interactive, powerful, and intuitive. Language barriers are less of a problem in an interactive environment utilizing pictures, animations, sounds, graphs, words and numbers where science can be seen, heard and explored. Engaging students more fully in thinking and problem solving will allow them to learn better. Also, techniques, concepts and demonstrations which are too expensive, dangerous, or do not lend themselves to traditional modes of instruction can be taught despite pedagogical obstacles. Project results will be disseminated through publication, professional presentations, and made available nationally over the Internet.

Unified Introductory Calculus and Physics

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DUE-9455564
FY 1995 $ 105,292
Interdisciplinary

A team of Occidental faculty in physics and mathematics are constructing a unified freshman program in physics and calculus. The students in the program are those with some deficiencies in pre-college mathematics and science preparation, but who might be motivated to

pursue a science or mathematics program as a background for a variety of careers, including medicine, and K-12 teaching. These students are disproportionally female, Latino, and African-American, groups which have long been underrepresented in mathematics and science-based careers. The students enroll in a year-long course consisting of four units in the fall semester and eight units in the spring semester. The pace is relaxed to permit students time to consolidate their mathematics skills and develop physical intuition. In addition, the course includes appropriate use of technology for analysis, simulation and calculation, carefully designed group assignments and projects, and frequent writing assignments. Further, the students are offered the opportunity to share a corridor in a campus residence hall. Employment of upper-division science students as teaching assistants and residence hall staff helps to integrate college learning with college life. By the end of the program, the students will have a solid understanding of how calculus and physics develop from a few fundamental ideas, and how the disciplines are interrelated. They will develop the mastery of basic math, physics, and communication skills necessary to support these intellectual goals. More importantly, the students will develop attitudes and learning styles that will support further study and success in science and mathematics.

General Education Course Development for Earth System Science and Global Change

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DUE-9455714
FY 1995 $ 100,001
Interdisciplinary

Undergraduate science education for both students majoring in science and engineering, and those students who are non-science majors must evolve to bring students in contact with the tools needed to efficiently grasp critical and emerging scientific issues. In 1991, the University of Arizona started a two-semester sequence "Introduction to Global Change" to teach non-science majors about the Earth system. The course teaches basic scientific principles in the context of global problems and challenges facing scientists, policymakers and citizens alike. The current project further develops this general-science course sequence in order to more fully integrate information technologies into the courses, and to explicitly design materials that promote collaborative learning and critical thinking skills through several different instructional strategies. PIs are working with an independent, professional evaluator to develop and implement ten modules for the two-course sequence. A module is a course unit focusing on a single topic, and involves laboratory sections, lectures, homework, discussions or other resources. The focus of their efforts is on: (1) developing computer-based laboratory exercises as the centerpieces of the modules; (2) implementing the computer-based tools with the classes; (3) assembling and preparing the additional material needed to complete each module (e.g., visual aids, study questions, background material, references); and (4) documenting each module in a workbook for the classes. The workbook, including documentation of software and data, is being made available to faculty at other colleges and universities interested in developing similar global-change courses. An important aspect of this project is the explicit assessment of the

effectiveness of different instructional strategies on students of different gender, ethnicity, and socioeconomic class.

Taking Ownership: Science as Constructive Inquiry (SCI) - An Interdisciplinary, Urban, Multicultural Curriculum Development Program

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DUE-9455430
FY 1995 $ 226,589
Interdisciplinary

Brooklyn College is developing, enhancing, and disseminating an intensive, yet supportive, science preparation sequence for urban preservice elementary teachers. For the past five years, college faculty from the four science departments—physics, chemistry, geology, and biology—have collaborated with the science education faculty to design and pilot a constructivist-oriented set of science and science education courses. The purpose of this project is to consolidate the successes of this preliminary program, to build upon pedagogic discoveries, and to strengthen and disseminate a possible major contribution to the Nation's infrastructure in science. Quantitative thinking is being developed as a systemic strand through science courses; this involves the use of lab-based science instruction as a way of teaching mathematics, and using mathematics as a way of allowing active learning to extend beyond the bounds of lab and human scales. The PIs are cooperating with colleagues concurrently working on revision of the mathematics sequence for elementary education majors. Since teaching in the constructivist mode involves a major shift for most faculty, the PIs are working to enhance consistency in teaching throughout the science courses. The science faculty are developing a revised model for setup of laboratory work, to allow for flexibility and spontaneity in student activities. The PIs will prepare a book about their experiences in devising a constructivist curriculum, including discussion of pedagogical, scientific, philosophical, and political issues. In addition to curricular illustrations, the book will demonstrate how faculty with traditional backgrounds can be encouraged, motivated, and taught to develop teaching styles appropriate to inquiry-based learning.

Multimedia Computer-Assisted Instruction in the Geosciences for Undergraduate Education

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DUE-9455665
FY 1995 $ 100,000
Interdisciplinary

This two-component project is improving geoscience teaching at the freshman and sophomore levels, particularly for non-science oriented students. A study of concepts and misconceptions brought to the course by entering students using surveys and interviews is being

completed. Investigations have discovered some unexpected, "pre-science" misconceptions. Students with the least prior contact with science are likely not to accept or effectively use fundamental assumptions held throughout science like the universality of the most basic laws in time and space. The second component will use the results of this study to guide the creation of computer-assisted teaching modules, initially one on coastal processes and one on mountain building. These modules are interactive multimedia programs which promote participant learning. "Virtual" field trips, animated simulations of processes, and interactive mathematical effects are being constructed. Recognized conceptual problems are being addressed directly, particularly through repetitive interactivity. Branching lines of study are triggered to fill in remedial background for those who need it. Authorware Professional is the intended programming tool for the highest level multimedia interactions. The project will be evaluated by repeating the survey approach. The teaching modules will form the basis for publishable CD multimedia programs.

Pacific Northwest Environmental Studies Program: A Collaborative Interdisciplinary Curriculum Development Project

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DUE-9455726
FY 1995 $ 121,511
Interdisciplinary

The Pacific Northwest Environmental Studies Program (PNESP) is an undergraduate curricular collaboration among four Pacific Northwest higher education institutions: Portland State University, Oregon Institute of Technology, Clatsop Community College, and Lower Columbia College. The program addresses the need to prepare students to enter one of the region's principal growth industries, environmental technology. This academic partnership allows the participating schools to pool their resources, field work opportunities and expertise to deliver a fully-transferable two-year curriculum in more depth and with broader scope than is possible without the collaboration. The curriculum development process includes both academic year meetings and summer faculty development programs that engage faculty from all participating campuses and involve professionals from the environmental industry. Thus, the program fosters the concept of an environmental teaching, learning, and service community among the faculty, students and industry professionals. The PNESP opens an avenue of seamless transition for students from precollege programs to upper division coursework. The PNESP core courses also serve to prepare students to enter teacher education programs that are aligned with Oregon's K-12 Natural Resource Systems Certificate of Advanced Mastery. The PNESP curriculum of introductory courses and field experiences will become the core element in environmental baccalaureate, associate and certificate degree programs encompassing science, policy, technology, and engineering on the participating campuses.

MATHEMATICS

The Mathematics Archives Outreach Program: A Program of Dissemination and Education about Mathematics on the Internet

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DUE-9550943
FY 1995 $ 100,000
Mathematics

The Internet is becoming an increasingly fertile source for information and tools of use and interest to the mathematics community. These resources range from programs and class notes to data sets for statistics and discussions of timely topics vital to the mathematical community. Many persons who would benefit from these resources are unable to do so because of a lack of knowledge of what is available and a lack of understanding of how to access items on the Internet. Based on experience with the Internet in establishing and running the Mathematics Archives, this project is informing the mathematical community about available resources on the Internet and educating them on how to access those resources. This is being accomplished by presentations at sectional meetings of the MAA and running special sessions, workshops, and minicourses at national and regional meetings, such as those of the MAA/AMS, AMATYC, and ICTCM. The impact of this program on the mathematical community is expected to be substantial.

A Modular Interactive Text for Linear Algebra

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DUE-9455618
FY 1995 $ 199,914
Mathematics

Mathematics educators from Grinnell College, The University of Washington, and Seattle Central Community College are developing an interactive linear algebra text. The text is organized in clusters of individual modules to facilitate its adaptation to many different curricula. The goals of the project are: (1) to help students develop their geometric intuition about the concepts of linear algebra; (2) to deepen their understanding of the algebraic formulations of these concepts and strengthen their ability to manipulate them; and (3) to help students gain an appreciation of how the concepts and methods of linear algebra are applied. The text is constructed using *Maple V*, enhanced by a supplementary package with superior text-handling and screen-layout capabilities. The text is designed to support collaborative learning and writing to learn. Many exercises encourage experimentation and exploration and ask for written hypotheses and conclusions. The entire text is being made available through the Mathematics Archives and will be readily available to all by *ftp* and *gopher*, and through the World Wide Web. In addition to being appropriate for all students majoring in science, engineering, and mathematics, the text is appropriate for students preparing for careers as secondary school mathematics teachers and is being tested with preservice teachers at all three institutions.

Teaching with Original Sources in Mathematics

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DUE-9354330
FY 1994 $ 67,204
FY 1995 $ 21,570
Mathematics

This project is developing an innovative lower-division mathematics course based on the study of original mathematical texts. The course provides an introduction to mathematics by examining the evolution of selected problems that fueled the development of several branches of mathematics. This class serves as a general education course for students in any major who have a solid high school mathematics background and provides a stimulating alternative to the standard mathematics course offered to liberal arts majors.

Mathematics Without Calculus

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DUE-9455305
FY 1995 $ 204,386
Mathematics

Faculty are producing, evaluating, and disseminating an interdisciplinary mathematics course for students whose major does not require calculus. Many of the ideas from calculus, such as rates of change, are included. The goals are to provide students with an appreciation of the intrinsic worth of mathematics, expose them to real applications of mathematics, and empower them with the quantitative and qualitative skills necessary for analytical and mathematical reasoning. The course is not to be a broad survey of either mathematics or its applications; rather, it focuses on a few significant and timely applications of mathematics provided by professions from agriculture, biology, business, chemistry, engineering, music, physics, political science, and zoology. A key feature of the course is the implementation of modern technology to provide students with fundamental tools such as graphical analysis, which have broad applications and allow a diminished role for traditional drill and calculation. One product of the project will be a commercially published text.

Principles and Practice of Mathematics

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DUE-9354509
FY 1994 $ 192,851
FY 1995 $ 157,956
Mathematics

A two-semester introduction to the principles and practice of mathematics is being developed for students who wish to study a significant amount of mathematics, including majors and minors in mathematics, computer science, and many science and engineering disciplines. This course, designed as an alternative to the standard calculus sequence route into the

mathematics curriculum, stresses breadth, and includes many of the areas of modern mathematics and applications that are currently "homeless" in the mathematics curricula. The design, review, field testing, and production of the course are being overseen by an advisory/editorial board and author team with a wide range of mathematical expertise and writing experience. Extensive outreach efforts include regular mailings, presentations at professional meetings, and faculty enhancement workshops. The project will culminate with the dissemination of materials by a major textbook publisher.

Development of a Course Sequence in Fractal Geometry for Interdisciplinary Undergraduate Education and Increased Mathematics and Science Literacy

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DUE-9455636
FY 1995 $ 203,562
Mathematics

This project is building on the inherent interest in fractal geometry by creating materials for a series of three fractal-based undergraduate mathematics courses: an introductory pre-calculus course emphasizing concepts, visualization, and interdisciplinary connections, particularly to art, music, philosophy and economics; a post-calculus course presenting the same material at a deeper mathematical level; and an upper level course on the applications of fractals and chaos including a detailed examination of data analysis and modeling. All courses make extensive use of computers in lecture demonstrations and in student homework. Platform independent graphics software is being developed to facilitate this program. Detailed instructor lesson plans are being developed and tested.

Chance: Current Studies of Current Chance Issues, Phase II

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DUE-9354592
FY 1994 $ 99,969
FY 1995 $ 109,945
Mathematics

This project is developing a course called Chance that introduces probability and statistical ideas in the context of issues reported in the daily press such as the use of DNA fingerprinting in the courts, the possibility of power lines causing cancer, the methods used to test for AIDS, and the interpretation of political polls. Students read accounts of current Chance issues in newspapers and scientific journals, and give their own critical analysis before discussing the issues with faculty.

To assist others in teaching a Chance course, a bi-weekly Chance newsletter that abstracts current Chance issues in the news is available by e-mail. Previous issues of this newsletter and other materials useful for teaching a Chance course are maintained on a Chance database on the Internet available by gopher and through the World Wide Web.

Evaluation of the Chance course uses a statistical reasoning assessment survey developed by Clifford Konold as part of the NSF-funded ChancePlus Project. The survey is given to students at the beginning of the course and again at the end of the course to show how attitudes and abilities related to statistical and probability reasoning have been changed. In addition, students are given, at the beginning and the end of the course, a newspaper article to read and a series of questions to answer to measure the impact of the course on the students' ability to read the news critically.

The Chance course has been taught at Dartmouth College, the University of California, San Diego, the University of Minnesota, Princeton University, Spelman College, Grinnell College, and Middlebury College. This second phase of the project is continuing development of the Chance database and preparing a teachers manual. The course will be discussed at national meetings and will be the subject of a workshop to identify other schools interested in testing the materials by teaching the course.

State University of New York (SUNY) Pre-Precalculus Program: Empowering Underprepared Two- and Four-Year College Mathematics Students

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DUE-9455638
FY 1995 $ 184,393
Mathematics

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The State University of New York (SUNY) Pre-Precalculus Project is aimed at a large and growing number of mathematically underprepared and/or unmotivated students, particularly women and minorities, at both two- and four-year colleges. These students did not succeed in mathematics courses in high school and continue to fail to achieve in similar courses such as introductory or intermediate algebra at the college level. To address their needs, this project is developing a new approach to pre-precalculus. It features a revamped curriculum involving contextual problem solving, an integrated use of technology, an improved pedagogy emphasizing active, collaborative efforts by students and faculty, and authentic assessment tied more closely to the course and "real world" skills. A series of curriculum development workshops over a two-year period is addressing these issues. The goal of the project is the design of a sequence of two four-hour pre-precalculus courses and the compilation of the instructional materials to support them. These two courses are replacing all developmental college mathematics courses prior to precalculus. A coalition of 12 SUNY two- and four-year colleges are site testing developed materials over the two-year period. Student assessment is through portfolios, projects, presentations, papers and concept maps. A National Advisory Board is overseeing the development of course and curriculum materials. The model and materials developed by the project will be disseminated throughout the SUNY system and nationally through papers and presentations at professional mathematics conferences.

Curriculum and Pedagogy Reform at Two-Year Colleges: Moving Beyond Myths to Standards

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DUE-9255850
FY 1993 $ 80,515
FY 1994 $ 10,175
FY 1995 $ 34,320
Mathematics

The recent focus in the mathematical community on calculus and the development of the National Council of Teachers of Mathematics Standards for K–12 teachers is providing a framework to consider mathematics courses taught at two-year colleges, and lower-division mathematics courses taught at other institutions of higher education in this country. These courses are important elements in continuum and pipeline issues, as well as general mathematical needs of students not continuing in mathematically oriented fields of studies. The American Mathematical Association of Two-Year Colleges (AMATYC) is undertaking a leadership role in designing a framework for systemic reform of college mathematics in the curriculum leading to calculus. The first stage is a meeting of an AMATYC National Steering Committee consisting of leaders of AMATYC and other mathematical societies actively involved in the development of innovative mathematics curricula and standards, particularly at the undergraduate level. In the second stage, a small National Task Force is being convened to establish guidelines for the development of a set of standards for two-year college and lower-division mathematics and to formulate a plan to build consensus for mathematics reform among two-year college and university constituencies. These standards are being disseminated and discussed at national meetings of the mathematical societies and revised based on feedback from this community.

Progressive Precalculus Problem Sets for High School and College

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DUE-9354741
FY 1994 $ 43,277
FY 1995 $ 54,871
FY 1996 $ 51,852
Mathematics

This project is developing progressive problem sets and innovative classroom exercises for use in high school and college precalculus classrooms. These materials present concepts from various points of view, emphasize writing, use technology where appropriate, encourage the use of collaborative learning, and stress the application of mathematics to other disciplines. Compatibility with current innovative calculus curricula, guidelines presented in the National Council of Teachers of Mathematics Standards, and current research on the ways people best learn mathematics are being used to evaluate the problem sets as they are developed. The materials consist of homework and in-class problems, as well as complete solutions and suggestions for use. The problem sets are being pretested as they are developed; workshops for both college and high school teachers, designed to demonstrate the materials and generate feedback, are being held; and a year-long piloting project is being conducted that involves at least three four-year colleges, one community college, and nine high schools.

Mathematical Interactive Network Design (MIND): A Computer Lab for Developmental Mathematics

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DUE-9455606
FY 1995 $ 75,394
Mathematics

The Mathematical Interactive Network Design (MIND) Project is a computer laboratory designed for *adaptive* interactive multimedia in developmental mathematics. The project uses SIMPLE, a new authoring system designed by Drs. Marion Hagler and William Marcy of Texas Tech University utilizing Visual Basic techniques. With object-oriented programs developed by supervising instructors, students use a graphical user interface and icon-driven software to access and work with the various instructional media. The goal is to immerse students in an intensely interactive, but easily constructed, simulated learning environment. This project provides a supportive environment for developmental students who, according to previous studies, derive few benefits from a computer tutorial session based upon a typical drill and practice structure. MIND meets each student's specific needs by providing individualized tutorial sessions with appropriate, constructive, instructive, and timely feedback. This system includes a "computer guide" whose behavior and even personality can be made to adjust to the attributes of the learner and demands of the instructor. The guide monitors all student activities and directs the tutorial session in a manner statistically indistinguishable from an experienced teacher. The guide presents various combinations of interactive video, audio, graphics, and text. This combination provides the students with choices of lecture, practice problem solving, and review and testing as deemed necessary.

This guide-driven tutorial session platform is being used as the basis for a two-year project to develop and implement tutorials for Basic Algebra I and begin development of tutorials for Basic Algebra II. It is being monitored by an advisory board. When the Basic Algebra I tutorials are completed, they will be tested at Amarillo College and Blinn Community College. Evaluation will be a qualitative analysis of the system by the student users and teachers and also a quantitative analysis to see if there has been statistically significant improvement in the completion rate.

A Capstone Course in Statistics

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DUE-9455292
FY 1995 $ 29,960
Mathematics

This project establishes a prototype capstone course to synthesize mathematical, statistical, and computing lessons learned throughout the curriculum and to develop students' oral and written communication skills to the level expected of professional statisticians. The synthesis is achieved by having teams of students participate in eight inexpensive laboratory experiments emphasizing concepts of applied and mathematical statistics, mathematics, and computing. They also study technical writing and oral presentation modules and prepare formal written and oral reports. If a report is not of professional quality, the student is given

considerable feedback and required to repeat the report. All students leave the course with a firm understanding of the communication skills required of the professional statistician. All course materials are reviewed by members of an evaluation team consisting of an academic statistician, an industrial statistician, a professor of speech and a professor of technical writing. The evaluation team will also review the written reports and videotapes of the oral presentations.

Computer Supported Cooperative Learning Environment for Multivariable Calculus

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DUE-9455672
FY 1995 $ 100,000
Mathematics (LLD)

Computer laboratory projects are being introduced in all sections of the basic multivariable calculus course at the University of Michigan (1500-1700 students per year). The computer is being used as a discovery tool. The project's main features are: promotion of active learning and hands-on experience; visualization through computer graphics; gradually introduced *Maple* syntax; furtherance of conceptual understanding; critical thinking; and quantitative reasoning. Several activities are included in the project: developing a library of laboratory projects (long term—each project is to culminate with a problem applied to science, economics or engineering); developing and implementing cooperative learning techniques in the computer laboratory environment; developing and implementing motivational material suitable for feedback techniques in large lecture classes, using a workstation in every classroom connected to an LCD panel; writing TA and instructor manuals and videotapes; and creating an intensive TA and faculty training program. All materials are being written with the consideration that some students have no prior computer experience.

Mathematical Sciences: Geometry of Configurations, Polygons, and Polyhedra

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DMS-9300657
FY 1993 $ 30,000
FY 1994 $ 30,000
FY 1995 $ 30,000
Mathematics

The project involves investigations in the fundamental geometry of convex polytopes, configurations, and combinatorial aspects of symmetries. Applications are proposed for tiling patterns in a variety of contexts including architectural design and stereoscopic viewing. Another component of the project entails an undergraduate education activity in aspects of geometrical structure. The project is developing further instructional material in several areas of geometry suitable for students at the high school and junior college level. Activities for participation of teachers at these levels are also being carried out.

Teacher Preparation Archives Second Printing

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DUE-9455577
FY 1995 $ 6,900
Mathematics

From August 1991 to April 1993, CIRCE (the Center for Instructional Research and Curriculum Evaluation) at the University of Illinois executed a contract with the National Science Foundation under the title "Teacher Preparation Archives: Case Studies of NSF-Funded Middle School Mathematics and Science Teacher Preparation Projects." The funding of the nine campuses to develop exemplary programs for middle school teacher preparation was a singular effort on the part of NSF. This unique program highlighted both middle school education and teacher preparation. That project culminated in a report entitled "Teacher Preparation Archives: Studies of NSF-Funded Middle School Science and Mathematics Teacher Preparation Projects," by Robert Stake, James Raths, Mark St. John, Deborah Trumbull, David Jenness, Michele Foster, Sherry Sullivan, Terry Denny and Jack Easley. Targeted both for a general and specialist teacher educator audience, the report runs over 300 pages as a paperback book. An additional 1,200 copies are being printed for distribution to requestors, with advertising handled through mathematics, science, and middle school education organizations.

Mathematics Concentrations in Economics and Chemistry

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DUE-9455972
FY 1995 $ 25,000
Mathematics

This project is designed to enrich mathematics courses at all levels of the curriculum by incorporating applications to and perspectives from economics and chemistry, and to enhance the teaching of mathematical methods in economics and chemistry courses. In the first year of the project, development of curricular materials is being undertaken at Haverford and Princeton in economics and at the University of Chicago in chemistry. Development and dissemination of these materials is catalyzing formation of two coalitions, one for mathematics and economics and one for mathematics and chemistry. This project is developing sample materials which can later be expanded into a project for national impact. The project involves close interdisciplinary cooperation, participation of graduate and undergraduate students, and team-teaching through faculty sabbaticals. In particular, a workbook incorporating sophomore mathematics (multivariable calculus, linear algebra, and differential equations) with its applications to chemistry is being written by interdisciplinary teams for widespread dissemination.

A Planning Seminar for Faculty Participating in the Rollins College Quantitative Learning and Teaching Program

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DUE-9456000
FY 1995 $ 25,000
Mathematics

Faculty from nine different departments in mathematics, the sciences, economics, politics, and business are working together to establish interdisciplinary initiatives involving teaching and learning of quantitative skills. In the last two years, with support from the Bell South Foundation, participating faculty have gathered and studied materials on quantitative problem solving, have created instructional guidelines, established a resource center, brought in experts as consultants to address the faculty, established two computer-based classrooms, hired an instructional specialist to work with faculty, and recruited the first group of students to work with faculty on the project. An important component of this project is a summer seminar for faculty. This seminar series is being extended throughout the academic year to enable a larger number of faculty to participate, with the goal of extending participation to faculty in all departments.

Library for Interactive Studies in Mathematics

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DUE-9551273
FY 1995 $ 249,998
Mathematics (LLD)

This project addresses the problem of how to use new information technologies, in particular the World Wide Web on the Internet, to make new tools available to teachers, to encourage the use of those tools to enrich the quality of mathematics instruction at the undergraduate level, to more effectively reach larger sectors of the student population, and to expand pedagogy with new technology-supported styles of teaching and learning. The project strives to make existing interactive materials easily available, to extend them, and to create new materials focused on the level and the abilities of the students users. The Library for Interactive Studies in Mathematics and Science, based at the Institute for Academic Technology of the University of North Carolina, Chapel Hill, is being built on the World Wide Web over a two-year period. The library contains interactive workbooks on topics commonly encountered in undergraduate mathematics, from college algebra and pre-calculus through multivariate calculus, differential equations, and mathematical modeling. The library makes available to instructors all over the country a wide variety of interactive workbooks that they may freely use and distribute to their students. Workbooks, together with the program necessary to read them, are provided over the Internet instantly, and free of charge. The initial library holdings are 45 of the most effective experimental workbooks created for the MAA-sponsored Interactive Mathematics Text Project (funded by IBM and NSF, ILI-LLD grant USE-9150272). All needed information about the library is disseminated electronically via e-mail and discussion lists, as well as through presentations and workshops. The goal is to show teachers what can be done, to get them

interested in experimenting, and to teach interested faculty how to build their own interactive workbooks. Faculty are invited to join an initial core group of eight knowledgeable authors whose colleges are participating by piloting and testing materials. Materials are provided and a workshop is being held to prepare 16 new teacher/authors. An integral part of the development process is feedback from an editorial board directed to the authors.

Calculus, Concepts, Computers, and Cooperative Learning: Assessment and Evaluation in Terms of Dissemination Goals

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DUE-9450750
FY 1994 $ 113,080
FY 1995 $ 104,920
Mathematics

This project is engaging in assessment, evaluation, and research to determine the effects of calculus reform curriculum and dissemination activities from the previously supported Calculus reform project at Purdue University. Assessment activities are related closely to research into how students learn mathematical concepts and include studies of the role of the teacher as facilitator and the use of group learning. The current dissemination approach includes the preparation of an instructor's resource manual, workshops, and the continued growth and development of a network of implementers. A model is being developed for evaluation of student attitudes, performance, and conceptual understanding in comparison with students who took calculus in standard models.

Bridge Calculus Consortium Based At Harvard

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DUE-9352905
FY 1994 $ 141,847
FY 1995 $ 381,112
FY 1996 $ 299,212
FY 1997 $ 299,135
Mathematics

The Calculus Consortium based at Harvard University, has developed, tested and disseminated an innovative single variable calculus course. The course is currently being used at over 125 colleges around the country and abroad. Information about the Consortium's single variable materials has reached a large number of faculty at diverse institutions. The effort is now being expanded to include precalculus and the second year of calculus. The dissemination effort for this phase is being modeled on the workshops, minicourses, newsletters, test sites, and networking that have proved successful in disseminating information about the single variable calculus course.

Revitalizing Introductory Statistics for Engineering by Capitalizing on Interdisciplinary Cooperation and State-of-the-Art Technology

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DUE-9455578
FY 1995 $ 57,866
FY 1996 $ 92,134
Mathematics

A novel laboratory approach is being developed for the instruction of introductory statistics for engineers, with emphasis on problem solving, conceptual understanding, and the use of writing and calculation-and-plotting as acts of cognition. Through interdisciplinary cooperation, a closer link between statistics and engineering courses is being made for a great benefit to both. Finally, taking advantage of the capacities made available by state-of-the-art computing and multimedia technology, curricular resources are being developed that will increase students' interest, motivation, and excitement.

Gateways to Advanced Mathematical Thinking: Linear Algebra and Precalculus

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DUE-9450731
FY 1994 $ 236,029
FY 1995 $ 273,177
FY 1996 $ 272,978
Mathematics

This project is building on previous research and curriculum development work to develop flexible understandings of topics in precalculus, calculus, and linear algebra. Exemplary course materials are being produced using a modular approach to package the concepts and activities. Based on broad mathematical themes, these materials make use of constructivist pedagogies, involving cooperative learning, computer technology, and alternatives to traditional lecturing. Field testing of the curriculum provides sites for research into the way students learn the topics and environments for teacher enhancement.

Project Socrates: Improving Physics Education Through Interactive Engagement

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DUE-9253965
FY 1993 $ 104,149
FY 1994 $ 123,665
FY 1995 $ 119,692
Physics

Project Socrates is contributing to a critically needed national improvement in university introductory physics education through research on, and development of, interactive engagement methods for cost-effective mastery learning. In particular, this project is further developing, improving, and promulgating the Socratic Dialogue Inducing (SDI) lab method which has been shown to be effective in promoting student crossover to the Newtonian world. The focus is on mechanics and related areas (fluid statics and dynamics, oscillations and waves). The testing ground is General Physics I, a large-enrollment, non-calculus course for science (but not physics) majors (including prospective high school and middle school teachers). "Real-world" in-class investigation, well-controlled out-of-class research with paid student subjects, and in-depth case studies are being utilized. The goals are to (1) improve and systematize the Socratic-dialogue and SDI lab techniques; (2) collaborate with other instructors to modify the SDI method for various instructional settings; (3) improve and extend the laboratory modules and instructors guides; (4) disseminate the method widely by means of publications, talks, workshops, and distribution of videotapes and lab modules; and (5) continue the construction of computer force-motion-vector animations to assist laboratory and lecture instruction.

Peer Instruction: Stimulating Renewed Interest in Physics and Other Science and Engineering Courses

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DUE-9254027
FY 1993 $ 100,000
FY 1994 $ 100,000
FY 1995 $ 43,500
Physics

This project addresses the problem of widespread student dissatisfaction with traditional introductory science courses. Project work indicates that the primary cause of this problem is that too much emphasis is placed on problem-solving skills, while too little time is spent explaining and discussing fundamental concepts. As a result, students often memorize problem-solving strategies without understanding the concepts that underlie their manipulations. The passive lecture format generally employed in introductory classes further exacerbates the problem. This project addresses these difficulties by adopting a simple and effective instructional technique—ConcepTests coupled with Peer Instruction—that helps revitalize instruction and improve student understanding. The two principal objectives of the technique are (1) to expose students' common misconceptions about fundamental principles via ConcepTests,

and (2) to rectify these notions and promote greater understanding of fundamental principles through peer instruction.

The project is implementing this method in an introductory calculus-based physics course and has already collected massive amounts of data on students' attendance and improvement, and on the effectiveness of the technique. Preliminary evaluation of these data has shown that the new lecture format and its emphasis on conceptual understanding and student interaction have led to improved student performance both on conceptual questions and on traditional numerical problems. This initial investigation is continuing; methods and conceptual questions are being adapted and refined based on these preliminary experiences. The project is extending this work to include further detailed data analysis, as well as the compilation of a collection of ConcepTests covering the entire introductory physics sequence. The project is disseminating the initial research results in invited talks at various conferences, and detailed statistical analysis is being carried out and prepared for publication. Although results have only begun to be catalogued, instructors at a variety of institutions have already adopted the method with very positive results. In addition, the method has been implemented with positive results in the introductory physics course for engineering majors at the University of Massachusetts, Lowell by Professor Albert Altman. The success of the method in these various institutional settings indicates that the utility of the technique is not limited to any special audience and does not depend on student background or prior experience.

Project-Centered Physics Curriculum

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DUE-9455656
FY 1995 $ 52,248
Physics

This project addresses the development of five new upper-level courses in a renovated physics curriculum. Since only about 3% of students in introductory physics courses nationwide continue on to upper-level courses, the curriculum must be made more appealing and the aims broader. Traditional curricula have been directed almost exclusively toward the training of undergraduates for graduate school and thence to becoming "physicists." Without sacrificing that goal, the aims of the undergraduate program can be broadened to provide benefits to those who will apply their conceptual understanding and logical problem-solving abilities to a wide variety of future activities. Courses within the model Dickinson College physics major curriculum are to be project-centered, dealing with real-world topics that appeal to students' curiosity. Learning is motivated not by a vague possibility of future usefulness, but by an immediate need for understanding in order to deal with the course projects. This approach is an outgrowth of the Workshop Physics introductory courses developed at Dickinson College, a program that has been used at many other institutions. In a similar way, the new curriculum, the newly developed courses, the project modules, or supporting materials can be useful to other institutions. Projects included in the new courses overlap topics covered in traditional courses, but provide new emphases. For example, experiments with chaos are being incorporated into the dynamics course and magnetic resonance imaging is joining other modern physics topics in medical and radiation physics.

Course Modules in Apparatus Design and Experimental Techniques

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DUE-9552121
FY 1995 $ 94,547
Physics (LLD)

Insufficient attention is given in science curricula to training students, at an early stage, in the practical techniques of laboratory work. When students begin undergraduate research projects, industrial co-ops, and jobs, many are ill-prepared to construct, select, adapt, and use scientific equipment. This project introduces a series of self-contained course modules in practical methods that begin after the first year of college laboratory courses. Six foundation modules form a one year course: (1) materials, mechanisms and machining; (2) basic electronic circuits and measurements; (3) signals and electronics for signal conditioning; (4) computer-assisted experimentation; (5) introduction to metrology and transducers; and (6) optical systems. Upper-division elective modules are: (7) vacuum systems and surface technologies; (8) feedback control; and (9) lasers and optoelectronics. In five weeks, each module covers a small number of the most basic methods and technologies of a topic. There are 90 minutes of discussion, lecture, and demonstration and four hours of lab per week. Students document their practical experience through individual portfolios of their projects. The modular form of this course material makes it readily adaptable to other colleges, where further topics can be developed in the same format. Student lab manuals, exercises, suggested projects, lecture transparencies, demonstrations, software, designs, and parts lists will be available and continuously updated over the Internet.

Physical Science: Reasoning and Conceptual Patterns

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DUE-9455613
FY 1995 $ 69,678
Physics

This project is developing a one semester physical science course for non-science, especially elementary education, majors. This course represents an important element in IPFW's teacher preparation sequence. The course is designed to enable the elementary education majors to implement activity-based curricula following the new guidelines from AAAS and NSTA. The course is activity-based with investigations and exercises designed to elicit students' common sense ideas about the systems and situations, challenge those ideas where they disagree with the scientifically accepted ideas, and help the students construct a new understanding of the concepts, principles, and relationships that apply. A limited set of investigative and reasoning processes, e.g., making observations and inferences, proportional reasoning, and drawing, reading and interpreting graphs, is emphasized and used throughout the course. In order to get the students to engage in the appropriate reasoning and to give them sufficient time to undergo conceptual change and construct a scientifically acceptable understanding, only selected concepts, principles, relationships, and topics are explored. Several concepts and principles, e.g., area, volume, density, and conservation of mass, are examined because of their importance in both chemistry and physics. In addition, two fundamental topics, motion in a straight line and

the basics of compound formation, are studied to illustrate some of the contrasts between the two disciplines. The course materials emphasize pattern finding and analysis and are being designed so that the students have to use qualitative means to work the majority of the tasks encountered. During the second year of the project, students will be pre-tested and post-tested using an instrument designed by two independent evaluators. A students' manual and an activities/exercise manual are being developed and will be made available to other instructors on request. Reports on the project will be presented at state and national science teachers meetings.

Implementing Interactive Laboratory-Based Learning Techniques in Second-Semester Introductory Physics

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DUE-9455732
FY 1995 $ 57,900
FY 1996 $ 56,409
Physics

Research shows that students use formula-centered, problem-solving strategies that differ from those used by experienced scientists, and that the knowledge students gain in introductory physics is a randomly organized set of facts and equations, with little conceptual understanding and many persistent misconceptions. These problems persist even for students who have had physics both in high school and in college. Many approaches have been developed to overcome these problems and have met with reasonable success in small institutions or for particular professors. A challenge remains in transferring these approaches to larger universities. Also, graduate students, the future instructors of science, are generally inadequately trained as educators.

The goal of this project is to overcome these problems through the development of a teaching system that is standardized and made available to larger engineering schools, while also being appropriate for smaller institutions. The teaching method involves leading the students from concrete hands-on examples to conceptual understanding through group discussion. Students are taught how to think about physics problems with concepts related to everyday phenomena familiar to the student. Quantitative experimental results provide verification. Cooperative learning, found to increase participation by women and minorities, is emphasized. Graduate and advanced undergraduate students are brought into the teaching process as apprentices, and guiding materials are being developed to acquaint them with the teaching strategies being used. The project focuses on the calculus-based introductory E&M and optics course taken by over 300 science and engineering students annually.

Over a three-year period, the technique is being refined using student testing and interviews to determine what strategies are most successful. The results are being made available in a format designed to facilitate implementation at a variety of institutions. Test versions of the activities and sample discussions have been available on the World Wide Web since 1995. A standard of evaluation for conceptual understanding of electromagnetism, similar to the Hestenes mechanics evaluation, is being developed and will be made available through an AJP publication.

A New Model for Physics Education in Physics Departments: Improving the Teaching of Physics from Elementary Through Graduate School

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DUE-9354501
FY 1994 $ 764,370
FY 1995 $ 754,830
FY 1996 $ 796,330
Physics

This project is developing a comprehensive, multifaceted program to be conducted by the Physics Education Group in the physics department at the University of Washington. The program consists of a group of interrelated projects that focus on undergraduate course improvement, teacher preparation and enhancement, and university faculty development. The goals for the project are: (1) to expand knowledge of how students learn physics; (2) to increase student learning in the introductory physics course; (3) to prepare K-12 pre-service and in-service teachers to teach science as a process of inquiry; and (4) to improve the teaching effectiveness of present and future college and university faculty. These goals are being met by continuing the investigation of student understanding in physics. Results from this ongoing research guide the development of instructional materials for introductory physics students and for pre-service and in-service teachers. In addition, the project is conducting workshops for undergraduate faculty, inviting faculty interns for short-term visits to observe project activities first-hand, and producing a faculty development handbook to help prepare teaching assistants, postdoctoral research associates, and junior faculty for their role as physics instructors. Their book "Physics by Inquiry" was published in the Fall of 1995.

Interactive, Conceptually Based Multimedia Instruction for Introductory Mechanics on CD-ROM

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DUE-9455585
FY 1995 $ 157,690
Physics

This two year project is developing interactive multimedia tutorials for calculus-based introductory physics. They will be distributed on CD-ROMs that can be used by students at school or elsewhere on equipment that will be available to most students upon completion of the project. Extensive testing at many colleges has shown that students enter physics with many misconceptions about motion and force, and that conventional physics instruction produces little change in these beliefs. Not understanding the most basic concepts, they cope by rote memorization of isolated fragments and algorithms for solving problems. Physics education research indicates that the most effective learning occurs when students are active participants and construct their own conceptual models, in contrast to the passive environment of traditional physics lectures. This project is using new technologies and findings in physics educational research to provide a computer-based learning environment that facilitates students actively constructing the conceptual framework of Newtonian mechanics. They are introduced to basic

concepts through short video clips of actual events. This is being done using QuickTime, which only requires the proper software; no additional hardware is needed. Computer animations and graphics help illustrate various interpretations and develop the principles involved. Many of these involve confrontations with common misconceptions. Students interact with simulations and physical representations such as vectors, force diagrams, and graphs. With appropriate feedback and help, they are able to compare predictions made from their conceptual models with those of the Newtonian model and the real world. After learning the concepts, students are led through multiple-representation, problem-solving procedures (e.g., free-body diagrams, graphical analysis, etc.), step-by-step with feedback, and using mathematical models that are appropriate for their background and ability. These modules are being designed so that instructors can add their own examples. The programs will be adaptable to courses of different mathematical levels, ranging from high school to university. The final product will have both Macintosh and Windows versions. Initial programming will be done with HyperCard and Macromind Director. The programming of the final product depends on the most appropriate cross-platform authoring program available at that time. During development, modules are being tested with students at San Jose City College, who are mostly minority. Two university professors and two community college instructors are evaluating the initial overall design and the preliminary version of the complete program. Also, a workshop will be held at San Jose Community College for community college instructors to obtain their evaluations of the preliminary version.

Reform of the "Non-Calculus" Introductory Physics Course from a Constructivist Perspective

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DUE-9354528
FY 1994 $ 114,966
FY 1995 $ 98,796
FY 1996 $ 96,309
Physics

The majority of the problems with introductory science courses, and the non-calculus introductory physics course in particular, stem directly from the way instructors conceptualize the teaching and learning process. This project is constructing and implementing a new introductory physics course that replaces the standard non-calculus course at the University of California, Davis. The model is grounded in a constructivist theory of how learning and conceptual understanding actually develop in an individual student. The course must be taught within the constraints normally found at large universities, and thus serves as a viable model for other institutions. This project intends to transform the traditional non-calculus introductory physics course into a constructivist-based course; produce instructor and teaching assistant training materials in constructivist methodologies; produce a student textbook; and support and guide other institutions desiring to make these changes. The expected outcomes include an increase in students' conceptual understanding and appreciation of physics, an increase in math and critical thinking skills in students, and a pedagogically appropriate model of a science course for pre-service teachers.

Production of Short, Animated Videos for Physics that Illustrate the Application of Physics to Technology

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DUE-9455740
FY 1995 $ 34,215
Physics

This project helps bridge the gap between physics and technology by bringing physics-based industrial and practical applications to the introductory physics classroom. The teaching of such applications in physics courses is essential in order that students understand the value and use of physics in real life and should also make the physics learning process more enjoyable and easier. Most physics instructors at present do not devote much time to technological applications primarily because of class time considerations.

The project is producing several SVHS videotapes containing short animated sequences to illustrate the applications of physics in modern technology at a level suitable for introductory physics courses. Although the primary audience consists of undergraduate college students, the videotapes are also useful for high school science students. The tapes are being prepared primarily through the use of computer animation and SVHS video recording. Each tape contains 5-10 minute expositions of several devices such as compact disks, photocopiers, telecommunication devices, computer chips, computer displays and keyboards, laser printers, fiber optics, medical devices, etc. These tapes will ultimately be converted into laser disks by a commercial agency.

Extensive field testing of the video segments in classrooms at several universities and high schools will be employed to improve their instructional effectiveness and evaluate their impact. Once the project is completed, the resulting materials will be disseminated commercially to insure maximum availability and reasonable cost.

Activity-Based Physics: Curricula, Computer Tools, and Apparatus for Introductory Physics Courses

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DUE-9455561
FY 1995 $ 725,000
FY 1996 $ 525,000
FY 1997 $ 525,000
Physics

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Three related activity-based introductory physics curricula have been developed with major support from the U.S. Department of Education and the National Science Foundation. These are Workshop Physics, Tools for Scientific Thinking, and RealTime Physics. All three

curricula use the findings of physics education research, are activity-based, and have involved the design of computer hardware and software for investigation, data analysis, and dynamic modeling. This three-year collaboration between principal investigators at Dickinson College, University of Maryland, University of Oregon, Tufts University, and Millersville State University is extending, enhancing, evaluating, and disseminating activity-based curricular materials, apparatus, and computer tools for teaching introductory physics based on this previous work. The ultimate goals of this project are to continue full-scale efforts to improve the scientific literacy of introductory physics students through the mastery of physics concepts, investigative skills, and mathematical modeling techniques, and to motivate students to learn more science. Throughout the three-year period, a comprehensive dissemination program will be conducted to reach introductory physics instructors at high school and college levels through workshops, public talks, on-site visits to institutions, and journal publications. These dissemination efforts are being supported by the commercial distribution of products through J.C. Wiley & Sons, PASCO Scientific, Vernier Software, and Physics Academic Software. Particular attention is being given to developing physics activities suitable for courses designed for future technicians at two-year colleges and pre-service teachers. A five-person advisory committee meets once a year to evaluate the project.

An Innovative Introductory Physics Laboratory Course

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DUE-9455282
FY 1995 $ 447,189
Physics

This project directly addresses the problems of the negative perception of physics and the general lack of science literacy among the broad student population. The variation in preparation in math and science of entering students, and the underrepresentation of women and minority students in science and engineering are equally critical problems being addressed. This project primarily addresses those pre-college and college students who, by virtue of their background and poor high school training, have had little or no opportunity to experience the excitement and beauty of science as an approach to the world. They do not, in general, consider science or engineering as potential career choices.

The course is designed not only to improve the understanding and appreciation of the laws of physics, but also to provide an experience with the instrumentation and methods of modern science and technology. Modern sensors are used for motion, force, temperature, sound and electromagnetic field measurements. The sensors are interfaced to microcomputers, allowing the students to acquire data and analyze their measurements rapidly in order to explore alternative physical hypotheses. Teaching and learning strategies geared to the needs of this special population are developed. These strategies utilize new experiments which are both non-intimidating and rigorous. They are designed to be both discovery-based and goal-oriented, and to provide an introduction to the excitement and creativity of scientific investigation.

The results of this effort are adapted for and shared with a diverse urban population of high school teachers and their students and two-year college faculty and students. The Rutgers-Newark student body and the geography and demographics of the Newark area, coupled with significant outreach efforts, ensure a large minority student participation in this project.

Evaluation efforts range from analysis by invited experts in the field of science education through comparison testing to student interviews and follow-up on career choices. The New Jersey Institute of Technology, Essex County Community College, and several Newark high schools are collaborating with Rutgers in constructing similar microcomputer-based learning laboratories for their introductory physics courses.

Precision Teaching of an Introductory Physics

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DUE-9455470
FY 1995 $ 242,100
FY 1996 $ 80,700
FY 1997 $ 80,800
Physics

Some 40% of engineering students fail to acquire adequate grades in the required Introductory Electricity and Magnetism Physics course. This leads to a high level of repetition and student attrition from programs. The project seeks to improve performance by emphasizing fluency in basic skills through the techniques of "Precision Teaching". The program presents a large number of relatively simple problems and requires the student to strive for a high rate of correct responses. The rate criterion is believed to be key to success. A pilot program was first presented using pencil and paper; but is now presented by computer terminal with machine scoring, time keeping, and records analysis. The number of inadequate grades has been halved. The pilot program indicates that a level of success is strongly correlated with good intuitive understanding. An interactive computer-based simulation of the more difficult and intangible concepts of the electricity and magnetism course is now under development. Included are electric fields, magnetic fields, and the generalization from distributed to continuous charges and currents. The simulation may be student controlled as a tool for assisting with homework problems and is also being incorporated into the Precision Teaching program for presenting exercises designed to enhance intuition.

The existing Precision Teaching program, with the new simulation component, is being enhanced to better emphasize a ramping of problem complexity and skills sophistication. Mastery is to be used as the criterion of completion of each segment. The new program is being presented to groups of students, and the performance is compared with matched control groups. The general progress to graduation of some 2,000 students per year is to be tracked for three years to study the impact of Precision Teaching, to identify factors related to ultimate success, and to analyze short-term performance on the course at issue.

An advisory committee is being formed to guide the program. The program will be tested at other institutions with large engineering enrollments. A pilot study has already been performed at VPI. Towards the completion of the project, a workshop or conference will be organized on the application of principles of Precision Teaching to university-level technical courses.

Physics Resource Packets as a Pathway to Tomorrow's Education

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DUE-9455442
FY 1995 $ 100,564
FY 1996 $ 102,430
FY 1997 $ 34,323
Physics

Rose-Hulman has developed a pioneering "integrated" freshman year curriculum utilizing symbolic algebra and other powerful software. This curriculum now regularly employs active learning through cooperative group work. Little has been done, however, to carry such innovations into the sophomore and succeeding years. Technology is advancing ever more rapidly making it imperative that education be abreast of coming changes. Instructors are slow to change their teaching to include new techniques, due both to inertia and lack of time. The goals of this project are to: (1) reinforce and build on major freshman-year innovations, to maintain and build student confidence in using skills and technology with challenging problems; (2) increase student confidence in the power of technology to generate graphical representations, to manipulate complex expressions, and to re-analyze a situation with new parameters; (3) build student and faculty comfort with cooperative group work. Students need to realize that all major problems facing scientists and engineers today require team efforts; (4) provide faculty with resources to accomplish goals 1-3; (5) disseminate the resources developed in this project to a variety of educational settings; and (6) use materials generated by the Consortium for Upper-Level Physics Software (CUPS) project to further enhance the educational impact.

The specific objectives of the project are to: (1) provide "resource packets" for selected introductory and advanced Rose-Hulman physics courses. Each packet will contain class-tested strategies and examples. This will enable faculty to confidently assign and use resources which meet the goals of this project; and (2) make assignments each quarter in every section of selected physics courses: (a) four or more activities using symbolic algebra tools; (b) four or more graphical output activities; (c) four or more assignments adding simple effects and varying parameters; and (d) at least once-weekly classroom cooperative group activity.

Packet development is being done by a team of faculty from the NSF-sponsored "Foundation Coalition" (Rose-Hulman, Arizona State University, Mesa Community College, Texas Women's University, University of Alabama, and Texas A&M University). A two-day cooperative learning workshop initiated the project. In Phase I (1995), packets were created for six introductory/large enrollment courses. In Phase II (1996), packets were created for five advanced physics courses. Two students were used each summer to generate full *Maple* and *Mathematica* problem solutions. Phase III (1997), involves revision and evaluation. Evaluation will be made by both pre- and post-measurement. It will be publicized via e-mail (phys-L, listserve), and talks presented at summer AAPT meetings. A survey will be developed to track usage and satisfaction with packets.

Astronomy and Writing: An Innovative Approach to Science Instruction

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DUE-9253979
FY 1993 $ 34,000
FY 1994 $ 94,519
FY 1995 $ 47,884
Astronomy

This project helps incoming students develop critical thinking skills and a better understanding of basic scientific principles by constructing an astronomy workbook that utilizes both math and writing. At New Mexico State University, a large portion of the student body is Hispanic, so particular care is being given to constructing exercises appropriate to this group. The workbook utilizes the techniques of "Writing-Across-the-Curriculum" (WAC). Numerous investigations have found that a strong relation exists between writing and learning. Writing has also been shown to be an effective tool in physics and math instruction. The project is exploiting the values of writing as a learning tool in astronomy. The incorporation of WAC techniques into a beginning astronomy class, at this level, is a unique experiment. The intent is that the project will serve as a prototype for future efforts in the physical sciences at New Mexico State University and that the material developed will be transportable to other institutions.

Active Learning Environment for Large Non-Science Majors Astronomy Classes

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DUE-9354525
FY 1994 $ 107,437
FY 1995 $ 87,287
FY 1996 $ 78,688
Astronomy

Almost all universities teach large introductory astronomy classes for non-science majors. These classes are typically among the larger and more popular science classes aimed at non-science majors, and often constitute the last formal science education students will receive. Unfortunately, many of these classes are organized around lectures that demand little or no participation from the students, creating an environment in which the students resort to an uncritical memorization of facts. This project is developing an astronomy class aimed at non-science majors that actively engages students in critical thinking. Modern and relatively inexpensive CCD technology is being used at many universities to teach astronomy observation laboratories to small numbers of astronomy students. This project incorporates CCD technology into laboratories designed for large classes of non-science majors as a method of increasing student participation. It also takes advantage of the numerous computer classrooms available at most universities and expands laboratory analysis into a separate computer homework component. This component enhances the lecture material, increases active learning, and breaks down the barrier between lecture and laboratory. The project pays particular attention to the practical difficulties of achieving these goals in classes that may well enroll 200 students, most of whom are not exceptionally computer literate, and also focuses on the long-term maintenance of such an environment without burdensome and unrealistic demands on faculty time and other teaching resources.

Creating Effective Meteorology Laboratory Modules to Improve Curriculum and Enhance Student Transition into Upper-Division Coursework

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DUE-9551536
FY 1995 $ 305,000
Astronomy (LLD)

The operational and research activities within the field of meteorology are undergoing unprecedented and rapid change. An effective meteorological laboratory curriculum must reflect the latest innovations and theoretical applications of the users of the science. This project is developing a lower-division undergraduate laboratory curriculum that prepares freshmen and sophomores for upper-level study, provides these students adequate time to begin learning their chosen field of study, and supplements the existing curriculum with a balanced and necessary foundation in understanding the tools used for meteorological study. The specific objectives of the project are to: (1) design lower-division coursework in meteorology; (2) create a laboratory manual consisting of computer programs and forecasting techniques to be used in lower-division courses. These laboratories also are designed for maximum flexibility and expanded use in upper-division courses. (3) provide students with skills for an easier transition from sophomore to junior year; (4) encourage other community colleges to develop programs in meteorology; (5) encourage students who are not adept at mathematics to become interested in weather; and (6) motivate students to take higher level mathematics and physics. The project is producing approximately 20 new computer-based laboratory curriculum materials. The modules provide the foundation for the development of courses in weather analysis and forecasting and create new computer-based laboratory opportunities for existing courses in atmospheric science. Self-paced meteorology modules encompassing new technologies with standard universal concepts allow for individualized instruction of meteorology fundamentals. The modules contain lessons in understanding numerical models, forecasting techniques, and data acquisition and manipulation, and are portable to different types of forecasting laboratory environments. The modules give students an opportunity to begin to understand the broad implication of meteorology by piecing together the atmosphere's subtle nuances, and may encourage students to expand scientific literacy by taking mathematics courses that they otherwise would not have considered. The backgrounds of community college students who will benefit from the project include meteorology majors, educators, aviators, and people with an avid interest in meteorology.

Imaging the Universe: A New Curriculum for Undergraduate Astronomy Laboratories

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DUE-9455621
FY 1995 $ 81,660
Astronomy

The project extends and enhances the development of an innovative undergraduate astronomy curriculum based on CCD cameras and robotic telescopes. The emphasis of the new

curriculum is hands-on planning and analysis of the student's own images rather than traditional methods using observations from professional astronomers. The primary audience is the non-science major in large introductory courses. The project has three components. The first is revisions and additions to the new laboratory curriculum already written. Fourteen observing laboratories as well as fifteen computer-based tutorial exercises have been developed during the current grant period. Based on comments from teaching assistants and students who have used the draft version of the curriculum, existing labs are being revised and about fifteen labs are being added. The revisions attempt to make the hands-on approach more direct, make the mathematical level more nearly uniform, and better emphasize the imaginative and creative skills of the students. The new observing labs cover astronomical topics not yet addressed in the current manual, including orbits of minor solar system objects, properties of variable stars, variability in active galaxies, and spectral line observation of nebulae and bright stars. New computer-based laboratories include extensive use of the astronomy databases and images available over the Internet. The second component is the development of a software system to schedule and control an automated telescope system using commercially available hardware. The system will be completely self-contained and controllable from any site on the Internet. A prototype system for a custom mount and dome using a low cost PC has already been developed. The system will allow interested colleges and universities to set up a complete CCD-based laboratory for large introductory classes with minimal effort and expense. It can also be used to operate remote dark-site telescopes which could be shared among several schools. The third component is the development of an HTML Internet site at the University of Iowa for dissemination of on-line information related to the use of CCD cameras and robotic telescopes in the teaching of astronomy.

TTECCS: Transforming Technical Education with a Classroom Communication System

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DUE-9453881
FY 1994 $ 302,000
FY 1995 $ 402,860
Astronomy

A classroom communication system is being developed to promote a more dynamic and constructivist classroom environment. Students engage in cooperative learning activities and communicate their understanding to the instructor, thereby permitting the instructor to respond to specific instructional needs. This project is a collaborative effort among science and mathematics instructors at the University of Massachusetts and Amherst Regional High School, educational researchers and curriculum developers at the University of Massachusetts Scientific Reasoning Research Institute, and educational technologists at Better Education, Inc. The project focuses primarily on the subject matter appropriate for a one-year astronomy course at the high school or college level. The complete system is being developed, consisting of hardware, documented software, and curriculum materials. Exemplar materials also are being developed in mathematics and chemistry. A primary aspect of the project is evaluation of the comparative effectiveness of the classroom communication system as an instructional approach.

A Hypertext-Based Study Guide for Introductory Astronomy: Defusing Misconceptions

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DUE-9455529
FY 1995 $ 27,337
Astronomy

The project is developing a database containing 100 highly-linked hypertext questions that provide a computer driven interactive study guide for introductory astronomy for non-majors. The goal is to complement traditional text and lecture materials with a new teaching tool designed to improve logical thinking by allowing students to explore and correct natural misconceptions. The hyperlinked environment enables: (1) presentation of multiple levels of information and reasoning; (2) the possibility for deeper exploration by motivated students; and (3) rapid feedback for the instructor and for the students. The 100 questions are selected to span the range of material commonly covered in introductory astronomy. This teaching tool can provide students with a visually attractive, intellectually stimulating alternative path for learning and honing their logical skills. The study guide is being made accessible via the World Wide Web. A controlled test of this instructional tool in an introductory astronomy course is being conducted. At the same time, it is being made available at all interested sites. The level of presentation in the study guide also makes it accessible to advanced high school science students.

Project CLEA: Contemporary Laboratory Experiences in Astronomy

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DUE-9354514
FY 1994 $ 197,800
FY 1995 $ 177,120
Astronomy

Astronomy is one of the most popular courses in the college curriculum for non-science majors and is for many students the first and only college experience in science. But laboratories in introductory astronomy are not conducive to hands-on experiments because of the faintness of astronomical objects, the long time-scale of many of the phenomena, and the fickleness of weather. Most current astronomy exercises rely on analysis of photographs or canned, predigested data, and give little feeling for the power and process of astronomical investigation. Existing exercises also make extensive use of photographs and other techniques that are out of date in the era of digital data acquisition and computer processing.

Project CLEA is developing computer exercises that provide realistic experiences for introductory laboratories based around simulations, digital images, and observations with CCD cameras on small telescopes. Six modules have been developed under previous NSF support, and six to eight are being developed under the current grant. Each module consists of software, illustrated student guides, teacher manuals, and technical documentation. Modules have been introduced into classes at Gettysburg College and distributed electronically to more than 600 individuals and classes worldwide, via ftp, dial-in bulletin board, and mail. The software is

evaluated through questionnaires (both for students and instructors), and the project also is conducting in-class testing at Gettysburg College and several other schools. A consultant is assisting in the development of evaluation routines that can be incorporated directly into the programs.

Currently, the most sophisticated modules run on PC-compatible computers under Windows. Under this grant the project converts existing and future software to color Macintosh versions. The new exercises improve students' understanding of astronomy and provide the means and impetus for revitalizing introductory astronomy laboratories nationwide.

An Interactive Introductory Astronomy Course

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DUE-9455293
FY 1995 $ 158,260
Astronomy

An introductory astronomy course is being developed whose primary goals are to: (1) develop quantitative reasoning skills and independence in problem solving; (2) expose students to the scientific use of computers; (3) inculcate an understanding of the power and limitations of experimental data; (4) develop critical thinking through scientific writing; and (5) build on the appeal of astronomy to attract and retain more science majors. The approach emphasizes hands-on problem-solving experience gained by working on projects built around a few themes, rather than the more passive learning inherent in delivery of a comprehensive body of material by a single professor in a traditional lecture setting. Students will be active participants in the classroom both collectively, through critical discussions of project goals, experimental techniques and analysis, and individually, through use of interactive software packages. The project makes extensive use of the hypermedia environment in developing software modules for the course, and eventually these modules will be available to colleagues at other institutions via the Internet. The course materials are being developed by a team of senior faculty and graduate students. The team approach benefits not only the undergraduates who are enrolled in the class, but also provides the graduate students with a mentored experience in designing courses and curricular materials, and thus a valuable introduction to teaching.

Planetary Exploration in the Classroom

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DUE-9455329
FY 1995 $ 109,270
Astronomy

Planetary exploration captures the imagination and interest of students having both science and non-science backgrounds and aspirations. Current textbooks that simply present a

few pictures from planetary missions fail to capitalize on the potential for utilizing the excitement of planetary exploration as a theme for learning about physical processes and the methods of science. This project is developing a curriculum that builds upon the appeal of space exploration to promote interest in science and to teach modern methods of scientific investigation and discovery. It uses a hands-on approach in exploring processes which shape planetary worlds using actual spacecraft images and existing Macintosh computers. Through a set of exercises, students learn that scientific images are no longer pictures in books. Instead, modern scientific images are digital objects that can be manipulated and examined in quantitative detail. Spacecraft images are used to motivate scientific inquiry but the curriculum also emphasizes that digital imaging is becoming inherent to areas beyond science. The new curriculum involving digital imaging is being incorporated into introductory-level classes which attract a broad cross section of science and non-science students. These students should carry their scientific and digital imaging experience with them as new tools in their pursuit of majors and careers in all areas of science, engineering, medicine, humanities, and education. Because the curriculum is at the introductory science level and uses both images and software available in the public domain (for both Macintosh and PCs), these exercises can be available for wide use in other colleges, universities, and high schools.

Integrating Geographic Information Systems into Undergraduate Environmental Science Curriculum

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DUE-9455331
FY 1995 $ 100,000
Social Sciences

Geographic Information Systems (GIS) computer programs are powerful tools for spatial data analysis and mapping that are widely used by environmental professionals. Specific GIS curricula, however, are not available for undergraduate environmental studies.

The goal of this project is to design, develop, and test an integrated set of core environmental science modules, incorporating GIS and related technologies. All components, lecture, laboratory, and field, are linked through the GIS in a multimedia framework.

Faculty design modules for a set of core courses in an interdisciplinary setting. Advanced students are involved in developing, testing, and implementing the new modules as teaching assistants in the core courses. Modules emphasize self-paced instruction, collaborative learning, group learning, and student-initiated projects. There are plans to assess the pedagogical effect of the integrated strategy. The student mentoring and alternative instructional strategies to be incorporated into the core curriculum are expected to make the Environmental Studies program more attractive to women and minority students.

The revised curriculum represents a significantly improved education practice for undergraduate environmental studies students, other science majors and non-science majors. Study of fundamental scientific concepts is integrated with study of management, decisionmaking, and ethics in a technically sophisticated framework. The project demonstrates how GIS can enhance problem solving, critical thinking and communication skills.

Nationally, this project can serve as a model for environmental science. There are plans to produce sets of interactive courseware and manuals that other programs can adapt to their own curricula. These will be disseminated electronically and through publications and workshops. Because the course materials will conform to a national consensus curriculum, other institutions should be able to incorporate them with minimal modifications.

A Laboratory Curriculum for Physical Anthropology on CD-ROM

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DUE-9354427
FY 1994 $ 128,179
FY 1995 $ 73,720
Social Sciences

This project expands and extends the reach of physical anthropology by developing a first- and second-year curriculum for use at other institutions nationally. The laboratories build on current course offerings and provide materials mastered by undergraduates as stand-alone modules on CD-ROM. These electronic laboratories permit students to work on specific problems using high resolution color images, video clips, three-dimensional animations, and

sound. It is also expected that the CD-ROM will provide these materials in an easily affordable instructional medium.

Networked Financial Simulation Using LambdaMOO Technology

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DUE-9455320
FY 1995 $ 168,703
Social Sciences

Given recent advances in network and MUD (Multi-User Domain) technology, it is now possible to build a networked simulation of the international financial system containing within it several simulated national financial systems. This project involves building a simulation called Money MOO.

Few current financial or economic simulations illustrate interactions inside the financial system as a whole. Fewer still combine national and international financial systems to illustrate their interconnectedness. Although the economic system itself is dependent on interactions among individuals and institutions, currently available simulations do not typically base their outcomes on that reality. Instead, most existing financial simulation software is designed to be used by an individual student working in isolation, not cooperating or interacting with other students.

Money MOO has the following characteristics: (1) The simulation is interactive and its outcomes depend on the combined decisions of the student-players. (2) The simulation is freely available to all educational institutions through the Internet. (3) The simulation is fun to play; it is a version of the most popular networked interactive game format which exists, the Internet MUD.

This networked simulation tool permits courses such as Introductory Macroeconomics, Money and Banking, and Financial Institutions and Markets to be taught much more effectively than they can be when the only available tools are textbooks and single-user simulations.

A Multidimensional Computer-Assisted Course for Teaching the Fundamentals of Ethnographic Field Research Methods in a Laboratory Environment to Undergraduates in Anthropology

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DUE-9455699
FY 1995 $ 200,000
Social Sciences

Cultural anthropology is grounded in field research. Most undergraduates never get the opportunity to explore the relationship between ethnographic theory and field methods by applying research methods in a field environment. This project addresses these limitations by developing an undergraduate course that combines classroom-based instruction and computer-based field research simulators used in a computer laboratory. The simulators complement

lectures, readings, and a course handbook that guides students through the lesson objectives. These materials are integrated into a year-long course on scientific field data collection methods and analysis and their relationship to ethnographic theory. The project further develops interactive computer simulators (a prototype has been developed) to recreate key aspects of the field research experience in actual peasant communities. These simulators allow undergraduates to "do" fieldwork, use theory as a framework for field research, analyze their own data, and manage limited resources in an interactive research environment. Nine hypermedia interactive modules are planned, each focusing on a significant research area. In navigating a module, students are constrained by the same concerns as an anthropologist in the field, e.g., budgeting of time and limited resources, formulating hypotheses to be tested, deciding who is a reliable and representative informant, and dealing with inconsistencies in reports of informants. Decisions made at each choice point affect the data collected. Development of curricular materials and simulators includes peer review and extensive consultation with technical experts available on campus to the PI. The materials are scheduled for extensive off-campus evaluation. The impact of this project is twofold: (1) scientific research methods, analysis, and theory can be taught hand-in-hand with actual field research assignments, and (2) students learn broadly applicable and transferable social scientific research skills, including the management and organization of computerized ethnographic data.

Developing Active Learning Modules on the Human Dimensions of Global Change

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DUE-9455632
FY 1995 $ 306,144
Social Sciences

The project actively involves faculty, global change scholars, and people with expertise in pedagogy in the development of introductory-level, activity-based course modules on the human dimensions of global environmental change and establishes a process within the Association of American Geographers (AAG) for the development, evaluation, and dissemination of these and other active-learning modules of introductory courses. The first goal addresses the needs to infuse recent global change scholarship into the introductory undergraduate curriculum, and it actively involves students in the learning process. The second goal seeks to address the current absence of any formal mechanism within the discipline of geography for the sharing of teaching and learning resources among undergraduate instructors. The principal expected outcomes are modules that speak to the three broad components of global environmental change: (1) the human and physical causes or driving forces of change; (2) the environmental consequences produced by these forces; and (3) the human responses to these environmental consequences. Central to these modules are the concepts of how human causes, environmental impacts, and human response vary by location (geographic area), and how the relationships among components are affected by the spatial and temporal scales of analysis (local, regional, global; decadal, centennial, millennial respectively). The project also establishes a clearinghouse within the AAG to disseminate the modules for use in introductory courses nationwide. The modules will be available to all instructors of some 500,000 students who are enrolled in introductory geography courses annually. Once this project is completed, the AAG clearinghouse will continue to develop and disseminate activity-based undergraduate learning materials.

Project on the Language-Art Interface: Vision and Voice—Rethinking Human Communication

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DUE-9455587
FY 1995 $ 123,680
Social Sciences

The Project on the Language-Art Interface (PROLARTI) focuses on the development of a prototype of a CD ROM, with the title: "The Origins of Communication," the first part of a three-part series titled: "Vision and Voice: Rethinking Human Communication." Designed for use by undergraduates in introductory level courses (in both traditional and long-distance classroom and home settings), "Vision and Voice" aims to encourage the exploration of language within an interactive, multimedia, interdisciplinary and cross-cultural environment. It links together the methods, theories and data of anthropology, biology, cognitive science, linguistics, literature, neurology and the visual and performing arts. In both its prototype and future CD-ROM formats, "The Origins of Communication" focuses on three broad areas of language: (1) Evolution; (2) Human Development, Language Acquisition, and Animal Communication; and (3) the Brain. All three areas of investigation include multidisciplinary material (theories, data, controversies) on visual and verbal aspects of communication. It is PROLARTI's first undertaking, which promises to provide a model for truly interdisciplinary research and teaching on language and to bridge the widening gap between the sciences and humanities. It plans to do so by redesigning scientific investigations of human communication to include the study of art alongside the study of language. When art is defined as "visual representation," its presence in all aspects of human communication (e.g., gesture) becomes apparent. Rather than simply emphasize similarities between language and art, PROLARTI's prototype for "The Origins of Communication" will focus on their differences as well. Language, being primarily a symbolic system of signs, stands in contrast to iconically-based systems, such as art. The shift in emphasis as exemplified by PROLARTI's prototype of "The Origins of Communication" aims to not only broaden the study of language to include all communicative processes—nonverbal forms (glossed here as "art") as well as verbal—but to expand the teaching of undergraduate courses on language by incorporating multimedia and interactive material from the life and social sciences as well as the humanities.

Quantitative and Experimental Modules for Undergraduate Education in the Human Sciences

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DUE-9455379
FY 1995 $ 150,000
Social Sciences

Undergraduate science education has two jobs. First it must prepare young scientists to continue their studies in one of the disciplines. But even more important, science education has a responsibility to the Nation to ensure scientific literacy. This project involves undertaking a

constructivist introductory program that lets students study quantitative and experimental aspects of human nature from the biological to the social at varying depths and breadth. The educational design consists of transportable but interdependent modules, each developed in collaboration with a nationally recognized researcher in the field, that require careful reading and analysis, occasionally of primary sources. There are also opportunities for a variety of complementary projects, field trips, computerized experiments and simulations, and summer studies in research laboratories that let students extend their science skills. Some of the CAI programming has been completed, and computer-based evaluation is in development. Novel testing techniques have been vetted in the pilot work and are being refined and extended. These evaluation methods test both students and the materials and serve to guide revisions and extensions of the modules. This model for teaching science is centered on subject matter of intense personal interest and delivered in a way that is at once serious, exciting, hands-on, and technically advanced. The modules use lectures, peer discussion, demonstrations, field work, and experimentation to teach the methods and results of science. Three modules have been completed and taught: two in biology and one in psychophysics. An extended assessment supports the effectiveness of the completed and tested units, in particular with minority and women students. The materials, when complete, will not only enhance science literacy in general, but will also permit admission to majors programs in biology, psychology or the social sciences. Portability and intermixture with traditional materials allow their use, individually or collectively, in a variety of venues. Student participation in the collection and analysis of data and concepts are central to most modules, thus departing significantly from audio-visual and electronic augmentations of classical lecture methods. These separable, but cross-integrated, units can be adapted to a variety of teaching contexts. This portability will be demonstrated by testing them at neighboring institutions during or immediately following this grant. Publication of the modular packages is currently being explored, possibly as separate units.

Introductory Microeconomics: The Way We Live

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DUE-9254299
FY 1994 $ 90,612
FY 1995 $ 19,466
Social Sciences

Economics teaches a way of thinking, "an ability to assess alternative choices in the face of constraints," that is fundamental to informed private and social choice. There is virtual consensus that an effective introductory economics course should teach students how to think intelligently and independently about economic issues. Yet, evidence suggests that the education community falls far short of this goal due to the increasingly encyclopedic and abstract nature of the material and a failure to respond to the experiences of an increasingly diverse student population. Moreover, the social and economic impact of increasing global interdependence is often ignored.

This project is developing an introductory microeconomics course that focuses specifically on the economic decisions that individuals make over the course of their lives. "Introductory Microeconomics: The Way We Live" introduces economic concepts and analytical tools within the context of specific choices students face, such as the decision to get married or obtain a

college education. Creating these connections between new information and personal experiences provides a strong motivation for learning. In addition, the course integrates exercises on numeracy and computer analysis, thereby providing an active, hands-on learning environment. The project can significantly enhance students' economic literacy, numeracy, and appreciation for cultural diversity by incorporating up-to-date data for such purposes as international comparisons.

SYSTEMIC CHANGES IN THE CHEMISTRY CURRICULUM—FULL GRANTS

A Workshop Chemistry Curriculum

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DUE-9455920
FY 1995 $ 425,000
FY 1996 $ 400,000
FY 1997 $ 400,000
FY 1998 $ 150,000
FY 1999 $ 150,000
Chemistry Initiative

The City College Consortium, which includes ten senior and community colleges at the City University of New York, and the Universities of Pittsburgh, Pennsylvania, and Rochester, is developing and applying widely a new model of teaching. This model, called Workshop Chemistry, introduces participation and mentorship by recent completers of the course. Small group, student-led workshops are integral to the course structure. Each week two workshops of one hour each complement the lecture and laboratory components. The workshop model provides a collaborative learning experience that increases student involvement and provides a new role for students as mentors. In Workshop Chemistry, students learn the problem-solving, communication, and teamwork skills crucial for success in the workplace, while learning chemistry more effectively. A prototype workshop model has been developed at City College in a general chemistry course for science and engineering majors, and is being expanded and refined for a broad range of courses including preparatory chemistry, chemistry for allied health sciences, organic chemistry, instrumental, and analytical chemistry. The experience of students as workshop leaders provides a natural introduction to teaching that is being formalized through a Teacher Preparation component of the project. The workshop method is also being exploited and applied in curricula for technician training, an initiative relevant to Advanced Technological Education. The project evaluates Workshop Chemistry and disseminates it beyond the bounds of the consortium. Student workshop manuals that include the problem-solving, model building, and simulation activities of the workshops are being produced for each course. New project partners will be invited to view workshops, to participate in faculty developments, and to implement pilot workshop courses at their own institutions.

Establishing New Traditions: Revitalizing the Curriculum

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DUE-9455928
FY 1995 $ 949,968
FY 1996 $ 899,999
FY 1997 $ 899,941
FY 1998 $ 499,941
FY 1999 $ 499,742
Chemistry Initiative

This project establishes new traditions in the chemistry curriculum that optimize opportunities for all students to learn chemical facts and concepts, develop and pursue interests in chemistry and chemistry-related disciplines, and appreciate how an understanding of

chemistry is important to life and living. The goal is to change fundamentally the ways students, faculty, and administrators view their roles and create a student-centered, active-learning emphasis. Addressed are five main areas that apply to all levels of the curriculum: student-focused active learning; inquiry-based/open-ended laboratories; interdisciplinary course clusters to create learning communities; a topic-oriented curriculum; and information technology/computer tools. Each development in each area is carefully evaluated, and only the best survive. Evaluation provides important information about the process of transfer of innovations among institutions of different types. To insure that the reforms planned are useful for all students, the consortium includes industry, public and private four-year institutions, minority institutions, and two-year colleges. The project gives special emphasis to students who choose teaching as a career option by mainstreaming these students in courses which benefit them in both content and pedagogy. Students, including those in Science Education, are fully integrated in the development and implementation of the project, working on both research topics and evaluation. The project also gives special emphasis to community college students in Advanced Technological Education (ATE) programs to ensure that they are given the newly developed curriculum. The students in the ATE program will clearly benefit by being provided the five main areas of thrust that this coalition is developing. All the students are expected to emerge with greater comprehension and better retention of chemical knowledge, improved ability to apply chemical concepts to new problems, enhanced appreciation of the relation between chemistry and other disciplines, and skills that enable them to work effectively in multidisciplinary teams.

ChemLinks Coalition: Curricular Reform Using Thematic Modules to Change How Undergraduates Learn Chemistry

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Chemistry Initiative

The ChemLinks Coalition is changing the way students experience the first two years of the undergraduate chemistry curriculum. Those "gatekeeper" courses enroll the vast majority of students who take chemistry, whether as a general education requirement, as a supporting course for another major, or as part of a chemistry major. Students must understand that chemistry is not a set of abstract and unrelated concepts to be learned; instead, it provides an intellectually challenging process for asking and answering questions related to their interests and to the needs of society.

This project is developing and testing modular materials about chemistry and the environment, chemistry and technology in society, and the molecular basis of life. With these modules, designed for students and faculty to use in a variety of institutional settings, the way students learn chemistry is being changed by challenging them to formulate and solve real

problems using active and collaborative learning strategies. By treating real, interdisciplinary problems of interest to students, scientific literacy for all students (both science and non-science majors) is promoted and the importance of science to society is demonstrated. Providing a model for students preparing for careers in teaching will have an impact on teacher preparation programs.

To change how students learn, the way that faculty teach and test must be changed. Many faculty need to become aware of significant educational innovations now underway—and of their efficacy. Even those who are aware of and committed to reform may be isolated. To achieve systemic change, individual and institutional barriers to reform are being identified and support is being provided through the Project Kaleidoscope national network. To disseminate the results and lower the barriers to curricular reform, the PIs are providing tested modular materials and new pedagogical approaches that can be adapted to local needs. Regional workshops train faculty to use the new approaches. Publications and presentations at regional and national meetings provide visibility and generate support for reform.

Project assessment documents the process of developing curricula, changing pedagogies, and institutionalizing change. It also records student reaction to those changes and the effects they have on student learning.

The ChemLinks Coalition of liberal arts colleges (Beloit, Carleton, Colorado, Grinnell, Hope, Kalamazoo, Knox, Lawrence, Macalester, Rhodes, Spelman, St. Olaf, Wooster) and research universities (Chicago, Washington-St. Louis) already has experience working collaboratively on chemistry curricular reform. Through collaboration with the Modular Chemistry Coalition of large public institutions and Historically Black Colleges and Universities, with the Advanced Technology Environmental Education Center's coalition of two-year schools, and with Project Kaleidoscope, the models and materials being developed, tested, and disseminated involve a large and diverse group of schools in making systemic and sustainable changes in undergraduate chemistry education.

Sweeping Change in Manageable Units: A Modular Approach to Chemistry Curriculum Reform

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DUE-9455924
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FY 1997 $ 705,000
FY 1998 $ 350,000
FY 1999 $ 350,000
Chemistry Initiative

The purpose of this project is to develop new curricula, materials and methods to enhance the appreciation and learning of science, especially chemistry, for every undergraduate student so that all college graduates will command the knowledge and skills necessary to permit continued learning, lead productive lives and make informed decisions. To accomplish this mission, this project is developing and evaluating a modular approach to teaching chemistry in the first two years of the undergraduate curriculum. Modules of one to four weeks present fundamental chemistry to students in the context of a real-world problem or application and emphasize the links between chemistry and other disciplines. In collaboration with the

ChemLinks Coalition, modules are being developed, tested and refined at the two- and four-year colleges and research universities comprising the two consortia. Curriculum materials, including text, lab, and multimedia components suitable for students from diverse cultural and ethnic backgrounds and usable at a wide variety of undergraduate institutions are being produced and distributed by an established publisher. Teaching methods which utilize current understanding of learning processes and emphasize active learning and the full spectrum of modern technologies are being supported, tested and promulgated. A model support infrastructure for development and assessment of new materials and methods is being provided. A framework for continuous improvement of curricula should result from the work and be institutionalized within the consortium. Faculty workshops and sessions at national and regional meetings are being conducted to guarantee dissemination. An overall evaluation plan is in place to test the effectiveness of the new approach and its effect on student learning and appreciation of chemistry, changes in faculty approaches to teaching, and overall science literacy.

SYSTEMIC CHANGES IN THE CHEMISTRY CURRICULUM—PLANNING GRANTS

Curriculum for Chemistry in a Large Urban University

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DUE-9455830
FY 1995 $ 49,929
Chemistry Initiative

A curriculum for chemistry at the undergraduate level is being developed to better prepare chemistry and biochemistry majors for employment through a novel Joint Industrial Chemistry Degree (JICD) which includes a two-year work experience graded by term papers and oral presentations. Majors are also afforded extensive research experience through a new undergraduate degree graded by thesis with an oral defense. These changes allow the intensive industrial and research degrees to be conducted off campus, and facilitate the path to a degree by economically disadvantaged students, by developing a module-based study sequence at the junior and senior level. The curriculum also introduces new technologies through extensive use of computers, and it improves opportunities for minority groups by using concepts adapted from existing Native American, Women in Science, and High School Outreach programs. Concurrent pathways at the freshman and sophomore level for non-science majors, life science majors including nursing and pre-meds, and physical sciences majors including pre-engineering are being developed. Close collaboration with the chemical and biochemical industry, other departments within the University, and community colleges and other four year colleges in the Pacific Northwest is a part of the project. Program assessment is based on methods developed in collaboration with a management consultant group. Results will be disseminated by peer-reviewed publications, monographs presenting upper-level modules, software publication and presentations at national meetings.

Planning Grant for Development of Systemic Undergraduate Chemistry Curriculum

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DUE-9455826
FY 1995 $ 49,248
Chemistry Initiative

This project places students at the center of their learning experience, and encourages both faculty and students to: (1) discuss and understand the importance of applied chemistry in our society; (2) participate in activities that encourage exploration and cooperative learning; (3) engage in a greater diversity of instructional strategies; and (4) exploit the role of new technologies as a means of implementing these approaches to learning. The curricular materials developed are based on a three-part balance between the factual aspects of chemistry (content), the role of chemistry in our daily lives, and the process by which information is located and discovered and by which problems are solved. The project develops a wide variety of resources

which draws students into all three of the above aspects of chemistry, and from which faculty may select material that best serves their own students and their interests and talents. The project focuses on content and concept sequencing, appropriate use of technology, educational strategies, and a structure for dissemination, faculty workshops, presentations and publications.

ChemPRIME: A Curriculum of Chemical Principles Through Integrated Multiple Exemplars

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DUE-9455822
FY 1995 $ 50,000
Chemistry Initiative

A consortium of nine institutions of higher education headed by Lehigh University is making fundamental revisions of the chemistry curriculum at all levels for majors in chemistry, for future professionals, scientists and engineers, for responsible citizens, and for continuing education students. The ChemPRIME curriculum utilizes current, high-visibility, multiple exemplars to structure the chemistry. Options in exemplars, depth and rigor of treatment, learning style format, review, self-testing, and evaluation create a flexibility made possible by CD-ROM technology. Students create self-customized courses. Ultimately a single publication integrates all courses in the curriculum. The planning process involves faculty in: (1) selection of exemplars for introductory and analytical chemistry courses; (2) definition of basic chemistry content covered in these exemplars; and (3) combination of exemplars into tracks through the courses in the traditional curriculum. The interdisciplinary nature of many exemplars promotes the integration of chemistry and related disciplines, while traditional core concepts allow reliance on the experience and training of faculty. The ChemPRIME curriculum creates courses of unprecedented flexibility because: (1) different exemplars treating the same basic chemistry are interchangeable; (2) depth and rigor may be selected by an instructor; (3) courses may be incrementally updated; (4) students select the presentation optimized for their learning style; (5) laboratory experiences are closely linked to exemplars; and (6) customized courses for new constituencies may be more easily designed and tested, broadening the impact of chemistry through the traditional college curriculum. Evaluation of individual components and the overall ChemPRIME project will be readily conducted. Student access to the developing program through a network will allow determination of component use and learning success via embedded self-testing and traditional methods.

MATHEMATICAL SCIENCES AND THEIR APPLICATIONS THROUGHOUT THE CURRICULUM

Mathematics Across the Curriculum

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DUE-9552462
FY 1995 $ 1,300,000
FY 1996 $ 700,000
FY 1997 $ 700,000
FY 1998 $ 700,000
FY 1999 $ 600,000
Mathematics Initiative

A thorough integration is being conducted of the study of mathematics with courses in physics, chemistry, geology, biology, social science, economics, art, music, philosophy, computer science, architecture, medicine, engineering, and literature. Engaged in the project are faculty representing these disciplines at a large number of institutions. Materials are being developed that are designed for use in conjunction with other texts, as independent reference materials, and as a basis for interdisciplinary courses. Support materials for faculty, including documented software, online materials, and videotapes, are being developed. The project is expected to result in fundamental changes at the institutions involved in the project. In addition, through the materials being developed and a series of intensive summer workshops, the project will benefit faculty and institutions other than those directly involved in the project.

Middle Atlantic Consortium for Mathematics and Its Applications Across the Curriculum

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DUE-9552464
FY 1995 $ 1,197,387
FY 1997 $ 499,653
FY 1998 $ 499,653
Mathematics Initiative

A consortium comprising the University of Pennsylvania, Villanova University, Polytechnic University, Community College of Philadelphia (CCP), two Philadelphia public high schools and the Society for Industrial and Applied Mathematics, has undertaken a major initiative to: (1) integrate research and real-world applications into the basic mathematics curriculum; and (2) achieve more effective integration of advanced mathematics and computing into the upper-level curricula of disciplines that use it.

The over-riding goal of this initiative is to promote a climate in which faculty across all disciplines view themselves as being jointly responsible for the education of undergraduates, rather than as clients and servants. The project will accomplish this first within the consortia institutions and then promote the use and development of such materials and methodologies at other institutions using the results as models.

The approaches are based on the experience accumulated at the University of Pennsylvania and elsewhere in developing and promoting large-scale calculus reform. The initiative consists of four projects: (1) creation of multimedia applications modules for mathematics courses and mathematics modules for other disciplinary courses; (2) development of basic and advanced interdisciplinary courses that integrate mathematics with specific applications areas; (3) development of applications and laboratory-oriented courses for mathematics majors; and (4) development of materials for non-mathematically oriented students in consideration of mathematical literacy issues.

Evaluation of project materials and results is to be carried out at the University of Pennsylvania by a group led by Robert Boruch of the Graduate School of Education, at Villanova by its Human Organization Science Institute, and by CCP's Office of Institutional Reseach.

Mathematics and Its Applications in Engineering and Science: Building the Links

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DUE-9552465
FY 1995 $ 1,210,000
FY 1996 $ 790,000
FY 1997 $ 700,000
FY 1998 $ 700,000
FY 1999 $ 600,000
Mathematics Initiative

The division of courses into many different departments often makes it difficult for students to grasp the intimate connections that exist between mathematics and its applications in engineering and science. Being developed is a library of interactive multimedia hypertext documents that will link important mathematical topics with contemporary interesting applications in various fields of engineering and science. This library will cover the mathematical areas normally studied by undergraduate students in engineering and science, including calculus, differential equations, mechanics and linear systems, advanced mathematical methods, and probability and statistics.

The library is the basis for a constantly expanding resource that supports a growing movement, at Rensselaer and elsewhere, to move away from a lecture-dominated mode of instruction to what is called, a "workshop" or "studio" mode. A traditional course often has several elements (lecture, laboratory, recitation) conducted by different individuals at different times and places, and are often only loosely linked together. A studio course seeks to eliminate the distinctions among these elements by combining them into a single whole. Typically a studio course also features exploration, discovery, and cooperative learning. The hypertext library is useful in a variety of contexts: (1) as a part of formal courses, but also for individual study, review, and enrichment; (2) in courses both in mathematics and also in the more applied disciplines of engineering and science; (3) in courses having a traditional configuration, as well as in more innovative workshop or studio courses; and (4) on two- and four-year college or university campuses and also in educational offerings at remote sites.

The development of these materials involves a collaboration among faculty at Rensselaer and initially, the University of Delaware, Siena College, Virginia Polytechnic Institute, Hudson Valley Community College, and the University of Maryland. Testing and evaluation of the

modules as they are produced and assessment of their effectiveness in helping students bridge the gap between mathematics and engineering or science are integral parts of the project. The World Wide Web will be the principal means of disseminating the library of modules. This will provide maximum access to students and faculty throughout the nation. Portions of the materials will be adapted for publication as CDs or in print form.

SCIENCE AND HUMANITIES: INTEGRATING UNDERGRADUATE EDUCATION

Integrating Curricula Through Southwestern Studies: A Faculty Institute

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EW-20339
FY 1995 $ 153,698
Science and Humanities

The Center for the Study of the Southwest at Southwest Texas State University is offering a four-week summer faculty institute in Summer 1996. Twenty-five college teachers from various disciplines will be invited to investigate how to break down the compartmentalization of traditional university disciplines through regional studies courses that draw upon the unique cultural, social, artistic, and physical nature of the greater Southwest. Faculty from various universities are helped to develop their interdisciplinary understanding and plan strong, innovative curricula that integrate science, social science, and the humanities and build intercultural knowledge. The Institute includes presentations by nationally recognized science and humanities scholars; large- and small-group discussions among participants, visiting scholars, and university professors; re-examination of core literary, historical, and scientific text they have read before their arrival at the Institute; and planning of curricula to make this intellectual substance available to students and other teachers.

The Institute concentrates on four topics: the Physical Southwest, the Historical Southwest, the Changing Environment of the Southwest, and the Cultural Southwest. Each topic corresponds to one of the four weeks of the Institute. Each weekly topic is investigated under the leadership of a distinguished teacher/scholar-biologist. They are Frederick Gehlbach, Baylor University, historian; David Weber, Southern Methodist University, environmental historian; Dan Flores, University of Montana; and film specialist, Don Graham, University of Texas. Each weekly discussion is capped by a field trip to a nearby site that relates to the topic of the week's discussion. Participants also study several key texts that relate to understanding the Southwest: the *Relación of Alvar Nuñez Cabeza de Vaca*, one of the key rare books in the Southwestern Writers Collection at Southwest Texas State University, and important literary texts that reflect the varied culture of the Southwest such as *All the Pretty Horses* by Cormac McCarthy, *Bless Me Ultima*, by Rudolfo Anaya, *Ceremony* by Leslie Silko, and *Desert Solitaire* by Edward Abbey. They also read and discuss books by the consultant scholars: *Mountain Islands and Desert Seas: A Natural History of the U.S.-Mexico Borderlands* by Frederick Gehlbach; *The Spanish Frontier in North America* by David Weber; and *Caprock Canyonlands* by Dan Flores. These works have been selected because they can be used as core texts in Southwestern Studies curricula to be developed by faculty at their home institutions and because each of the texts blends disciplines in different ways.

Human Nature: Integrating Nature and Nurture

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EW-20310
FY 1995 $ 207,200
Science and Humanities

Robert Perlman, University of Chicago

Scientists who map the human genome, observe primates in the field, analyze hominid evolution, or explore the dangers of environmental pollution often challenge traditional beliefs concerning human nature and society. Research on human behavior in the light of contemporary biology reveals complex interactions between individual, cultural, and environmental factors. No longer is it reasonable to think in terms of "nature versus nurture." Informed citizens and leaders will need to know more about the relationships between genetics, neuroscience, or ecology and the social sciences and humanities.

To encourage balanced and responsible courses in the area that relates biology, the humanities, and the social sciences, a Summer Faculty Institute is being developed. This six-week program is co-sponsored by the Rockefeller Center for the Social Sciences at Dartmouth College and the Gruter Institute for Law and Behavioral Research, two institutions that have cooperated in organizing interdisciplinary seminars since 1988.

Participants are 25 college and university faculty members committed to teach at least one course that approaches human nature from a perspective integrating the humanities, life sciences, and social sciences. There is a mixture of roughly one-third of the participants from each of these areas to insure that participants represent a variety of disciplinary interests and theoretical approaches.

Emphasis is placed on dialogue among the participants, on laboratory, computer, and observational exercises, and on small-group workshops exploring specific interdisciplinary issue areas. During the last week of the Institute, each workshop presents its approach to teaching the issues chosen for study, and each participant submits a possible course outline for discussion.

Genetic Technology: Scientific, Ethical and Social Challenges

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EW-20332
FY 1995 $ 143,500
Science and Humanities

Recent developments in molecular genetics are presenting society with a Pandora's box of difficult moral, social, and scientific questions. New dilemmas will face our students, whether they are scientists or humanists. Increasing academic specialization makes it less likely that students today will have the kind of integrated knowledge of the sciences, social sciences and humanities that these issues require.

The University of Puget Sound is developing a summer faculty institute which will integrate laboratory science into humanities and social science courses and at the same time promote the integration of the ethical and social implications of technology into science courses.

Central to the program is a summer workshop which combines laboratory demonstrations of genetic technology with seminar discussion of its ramifications. Hands-on experience with the technology is crucial to improving the comfort level humanities and social science faculty feel with genetic science. At the same time, the seminar introduces science faculty to the analytical tools of the humanities and social sciences

The institute is being taught by some of the leading figures in various fields. By exposing participants to the way that different disciplines examine genetic technology, the gap between the sciences and humanities is bridged. Scientists are introduced to the analytical tools, methods and texts of the humanities and social sciences, at the same time that humanists become familiar with the science.

Science, Culture, Society: The Modern Studies Curriculum

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EW-20320
FY 1995 $ 143,000
Science and Humanities

This project implements and assesses an experimental general education curriculum for college students that integrates the natural sciences, social sciences, and humanities. It seeks to develop both an integrated curriculum and a highly innovative pedagogy; both content and context are crucial to the project's success.

Large public research universities must provide undergraduate students, especially first- and second-year students, with a meaningful, intellectually engaging, and challenging academic experience rooted in a coherent liberal arts curriculum. Rather than offer courses that "cover" the intellectual domains of diverse disciplines, the goal is to develop an innovative, cross-disciplinary pedagogy with two characteristics: *intellectual integration*, such that all courses in the program are self-consciously cross-disciplinary; and *support of learning*, for which a novel mini-college concept is developed.

Developing an intellectually integrated curriculum goes beyond informing students of the differences among disciplines; rather, it shows how one discipline's study of some phenomenon may be enriched by the perspectives of other disciplines, including disciplines seemingly remote from the first. The effort to develop this curriculum is led by a multidisciplinary faculty team.

To foster a supportive environment, mini-colleges consisting of a small number of students and an associated multidisciplinary faculty team are being organized. Within the context of a large research university, the pedagogical advantages of a small liberal arts college are being recreated. This pilot project will become replicable for large numbers of students not by making the mini-college large, but rather by establishing a sufficient number of side-by-side mini-colleges with different topical foci.

Science, Technology and Society

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EW-20307
FY 1995 $ 120,000
Science and Humanities

Science, Technology, and Society is an established field at engineering and science colleges and institutes, but not at community colleges. This project addresses the following: (1) key BMCC science and social science faculty are developing the curriculum for four courses in Science, Technology, and Society (STS), and teaching them; and (2) the three project directors are planning two four-week summer workshops, one in-service and another for dissemination with several visiting scholars. The in-service workshop affords BMCC faculty from several departments expanded participation and immersion in STS. The dissemination workshop provides a forum in which to share the experience and knowledge of curriculum and faculty development in STS with community college faculty from other CUNY campuses. One advantage of this arrangement is that the curriculum for four STS courses becomes enriched by incorporation in workshops where further experience and performance data can be obtained from a dialogue in an interdisciplinary—science and humanities intensive—setting. Dissemination reinforces learning acquired by the project directors about the implementation of Science, Technology, and Society at the community college and permits the sharing of this knowledge with faculty at other CUNY campuses. Such faculty and course development benefits students registered in BMCC's science and engineering science associate degree programs. Another goal of the project is that the STS courses resulting from this project become electives in and should enhance both of these degree programs because of the integration of science and humanities education.

BMCC faculty, by virtue of acquiring knowledge of Science, Technology, and Society, will achieve competence to judge and appreciate its need, its innovative quality, and its place as a degree program in the community college of today and tomorrow. A traditional liberal arts degree affords wide humanistic study, but an associate degree in Science, Technology, and Society has that advantage and others such as providing the student with the scientific and technological understanding to participate as full citizens in our technoscientific age.

Gender Studies Core-Course Sequence: Examining and Integrating Disciplinary Perspectives

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EW-20321
FY 1995 $ 160,000
Science and Humanities

Cognitive tension, created by comparing specific disciplinary approaches with attempts to combine them, so they may actively draw upon and interrogate each other, forms the central conceptual problem that is guiding curricular development in the Gender Studies Interdisciplinary Area at Lawrence University. A multidisciplinary approach can show students

that different answers to like questions are possible, whereas an interdisciplinary one can encourage them to bring the disciplines together in an interactive way to develop new lines of inquiry. The Lawrence University Gender Studies Faculty is creating a dramatically revised sequence of three core courses intended to highlight how the disciplines can work both for and against each other when answering questions related to gender. An introductory course, "Knowledge of Gender," is a multidisciplinary survey of how various disciplines define, describe, and represent sex and gender. An intermediate course, "Gender of Knowledge," is an interdisciplinary examination of what happens when the assumptions of different disciplines are re-evaluated in light of the claims and findings of the others. A capstone experience for seniors, "Interdisciplinary Research in Gender Studies," asks students to apply multidisciplinary perspectives and interdisciplinary skills to focused research projects in their major fields.

The specific goals of the project include: (1) planning and implementing a new three-course sequence for Gender Studies at the beginning, intermediate, and advanced levels; (2) bringing together faculty from all four divisions of the university (natural sciences, social sciences, humanities, and the fine arts) to plan and teach these courses; (3) organizing week-long summer work sessions with guest speakers for involved faculty; (4) purchasing books, videos, and periodicals to provide necessary resources for faculty and students; (5) planning and implementing evaluation procedures during the course of the three-year grant period; and (6) disseminating the results of the efforts to other colleges and appropriate consortia. Assessment of these courses begin at the end of the first year. The university is creating a resource area on campus for the Gender Studies program to keep newly acquired materials available for faculty and student use. At regional conferences and consortia, participating faculty will present papers and workshops detailing the planning, implementation and results of these curricular changes. Faculty will also submit articles describing the program to appropriate scholarly publications.

Environmental Studies: Faculty and Interdisciplinary Curriculum Development

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EW-20313
FY 1995 $ 122,000
Science and Humanities

Eckerd College is implementing a comprehensive, 17-month program in Environmental Studies. The project's goal is to broaden faculty knowledge and expand interdisciplinary methodology in the field of Environmental Studies leading to the expansion of course offerings in the major as well as in the general education program. The program of faculty and curriculum development builds upon prior efforts to promote multidisciplinary and interdisciplinary thinking and teaching. The project includes faculty representing the humanities and social sciences as well as a curriculum development specialist and establishes interdisciplinary conversations about the field of Environmental Studies.

The project includes six phases: Phase I: Readings and Conversations in Environmental Studies, an opportunity for 16 faculty from humanities, sciences, social science, and natural sciences to read and discuss foundational works; Phase II: Interdisciplinary Faculty Seminar, a focused case study accompanied by cross disciplinary readings and interdisciplinary conversations exploring five overarching themes inherent in Environmental Studies; Phase III: Course Design in the major with a focus on the interdisciplinary Introduction to Environmental

Studies course; Phase IV: Curriculum Design for General Education Winter Term; Phase V: Course Design with a Focus on Internships and Service Projects and the design of the interdisciplinary senior capstone course Research Seminar and Senior Comprehensive in Environmental Studies; Phase VI: Conversations: Interdisciplinary Environmental Studies for a Changing World, Parts I and II, Winter Term Environmental Studies general education projects focused on local, national, or international case studies.

The primary intended outcome is to establish an interdisciplinary faculty development program integrating contributions from the humanities, natural sciences, and social sciences and focused on the development of a truly interdisciplinary Environmental Studies major. This case-study-based program includes the restructuring of the Environmental Studies major which is projected to be one of the three most heavily enrolled at the college. In addition, new general education courses highlighting environmental science and humanities literacy will be offered in the winter term, 1997.

Mathematics Across the Curriculum

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EW-20327
FY 1995 $ 169,000
Science and Humanities

The traditional mathematics curriculum from kindergarten through college fails too often to capture the imagination of many students who ought to be well served by our discipline. Worse still, passage through that curriculum too often brutalizes students, leaving many with an aversion to the subject and lifelong insecurities about using mathematical ideas and reasoning at all. This is a shame: mathematics arises naturally in almost every field. Unfortunately, many faculty in non-scientific disciplines count themselves among the brutalized and, consequently, steer a wide course around topics with latent mathematical content.

Over the last eight years, members of the Mathematics Department have worked together with colleagues from the humanities and social sciences in the creation and teaching of two interdisciplinary courses which have become centerpieces of Mount Holyoke's curriculum for entering students: Pasts and Presences in Western Civilization, and Case Studies in Quantitative Reasoning. During the teaching of these courses, an ongoing exchange of ideas on curriculum and pedagogy has taken place and grown to include a larger group of faculty and a broader range of disciplinary interests than those initially represented. For mathematics it is clear that adapting the pedagogy of the humanities to the mathematics courses can enliven the classroom environment and make the mathematical content more appealing and effective for a broader range of students. In the humanities a long list of topics can be identified within existing courses whose latent mathematical content currently lies neglected but which could be made explicit.

Sixteen faculty members from the mathematics and various humanities departments are creating a "Mathematics Across the Curriculum" program at Mount Holyoke College. This program is introducing students to applications of mathematics appearing in a variety of disciplinary settings and serve as a model for future efforts, at Mount Holyoke and at other institutions, to provide students with opportunities to grapple with mathematical ideas and reasoning in contexts drawn from the humanities. To begin this part of the project, mathematical

materials will be introduced into nine different entry-level humanities courses and students who ordinarily do not take mathematics courses will be allowed to encounter mathematical ideas in contexts which are useful, non-threatening, and intellectually engaging.

Humanistic Studies of Science: An Undergraduate Major

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EW-20349
FY 1995 $ 95,000
Science and Humanities

The aim of this project is to develop an interdisciplinary undergraduate major program in humanistic studies of science, technology, and medicine appropriate for the curriculum of a distinguished liberal arts college. The major will enable students to study the sciences as institutions, practices, intellectual achievements, and constituents of culture, by integrating the methods and perspectives of multiple humanistic disciplines and drawing upon a solid foundation of coursework in a science. History of science and medicine, philosophy of science, and social and anthropological studies of science and technology provide the disciplinary core of the major, but elective courses range more widely. The program is being made available as a self-contained major or as a joint major program with any of the natural sciences.

The project is an outgrowth of an NEH Summer Institute on "Science as Cultural Practice" held at Wesleyan in 1991. The project further develops and implements within a specific liberal arts institution the Institute's reflections upon how to bring together the perspectives of humanistic science studies both within individual courses from traditional disciplines, and as an undergraduate major. Wesleyan University is especially well suited to develop such a program, for the new major is a natural successor to an interdisciplinary Science in Society Program that reflected quite different scholarly approaches to the humanistic study of science and technology 20 years ago.

The new major includes three required core courses in historical, philosophical, and sociocultural studies of science, two additional elective courses in science studies, a minimum of four courses in a single scientific discipline, and either a four course area of concentration in one of the humanistic disciplines that contribute to science studies, or sufficient additional science courses to fulfill the requirements for a science major. Funding is requested to support the development of modification of three core courses and five electives (two of the core courses and three of the electives would be entirely new courses).

Two outside scholars will evaluate the new program. Revised course syllabi and descriptions of the overall program will then be made available to other college and university teachers and administrators over the Internet and through professional newsletters and other publications.

A General University Science-Humanities Curriculum

Michael J. Flower, Lawrence P. Wheeler
Portland State University
Portland, OR 97207
(503) 725-4928

EW-20331
FY 1995 $ 176,000
Science and Humanities

Portland State University is designing and implementing an integrated set of nine interdisciplinary courses—the Science-Humanities Curriculum—to bridge the two cultures of the sciences and the humanities and to become part of the full-scale reform of general education occurring at the University. That reform, already underway, has led to the creation of an Office of University Studies which coordinates and administers the new interdisciplinary general education curriculum taken throughout a normal four-year program of study.

Faculty are taking part in two sorts of interdisciplinary ventures. First, academic-year seminars make clear the intellectual issues surrounding the development of this new curriculum in order to promote participation beyond the faculty already involved in the project. Second, there are on-campus summer workshops leading to new course development. These feature immersion in requisite disciplinary and interdisciplinary content and teaching strategies (e.g., "writing to learn" techniques, effective use of collaborative inquiry methods, and state-of-the-art use of the computer for writing and modeling, as well as for accessing resources via Internet). Science-Humanities curriculum faculty are collaborating with faculty of the already-existing, NSF-funded Science in the Liberal Arts program, working to establish curricular links among the courses in the two curricula, and to clarify and enrich our understanding of the diverse intellectual issues arising at the intersection of 'science' and 'the humanities.'

The Science-Humanities curriculum provides students a sophisticated portrayal of the past, and present relationships between the sciences and the humanities; and brings together students and faculty from the Science-Humanities program and the existing NSF program. Students in the latter program have the opportunity to extend their science literacy in the direction of the humanities, and students with a primary interest in literature, philosophy, or theater (for example) explore paths of inquiry into the sciences from the solid interdisciplinary base of the Science-Humanities curriculum.

The Science-Humanities curriculum is offered at the sophomore and junior level and serves students who are not majoring in the sciences as well as those who are. In their sophomore years students begin with the overview course, "Framing the Two Cultures." That course introduces perspectives both on science inquiry, the methods of the humanities, and their useful interrelation and integration. Students complete at least three other courses from the program before the end of their junior year, thereby meeting roughly a third of their general education requirement with coursework from this innovative curriculum. Several of the new Science-Humanities courses are offered jointly in the Science in the Liberal Arts program and are available to students near the end of their interdisciplinary work in the latter program.

NATIONAL SCIENCE FOUNDATION
DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES

UNDERGRADUATE COURSE AND CURRICULUM DEVELOPMENT PROGRAM
FY 1995 AWARDS

Institution / City / *Award Title*	Project Director / Zip Code	Discipline / Department	Amount	Months	Award #
STATE NAME					
ALABAMA					
University of South Alabama Mobile *A Cognitive-Based Approach to Introductory Computer Science Courses*	D L Feinstein 36688	Computer Science Department of Computer & Information Sciences	$89,976	12	9455522
ARIZONA					
Arizona State University Tempe *New Engineering Statistics Course with a Virtual Computer Laboratory*	F Hubele 85287	Engineering Industry. & Management Systems Engineering	$100,600	24	9455393
Mesa Comm. College Tempe *Computer Applications to Enhance Inquiry-Oriented Laboratory Instruction in Biology at a Two-Year College*	W B Kincaid 85281-6941	Biology Department of Life Science	$83,177	42	9254228
University of Arizona Tucson *General Education Course Development for Earth System Science and Global Change*	L J Graumlich 85721	Interdisciplinary Institute for the Study of Planet Earth	$100,001	24	9455714
University of Arizona Tucson *Mathematical Sciences and Their Applications Throughout the Curriculum--Project Synergy: A Consortium Linking Engineering, Basic Science, and Social Science with Math*	D Hughes-Hallett 85721	Mathematics Initiative Department of Mathematics	$46,923	24	9455970
ARKANSAS					
University of Arkansas Fayetteville *Implementing Interactive Laboratory-Based Learning Techniques in Second-Semester Introductory Physics*	B Stewart 72701	Physics Department of Physics	$57,900	12	9455732

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CALIFORNIA

California Inst of Tech	N S Lewis	Chemistry	$100,000	24	9354453
Pasadena	91125-0001	Department of Chemistry			

Development of Computer Graphic Visualization Aids for the Undergraduate Chemistry Curriculum

Cal State U Los Angeles	R A Desharnais	Interdisciplinary	$200,000	36	9455428
Los Angeles	90032-4221	Department of Biology			

Integrating the Electronic Desktop into the Natural Science Curriculum

Film Arts Foundation	R Carranza	Engineering	$50,000	24	9455761
San Francisco	94103-3809	Department of Biology			

Silicon Run I 2 - An Educational Film about Integrated Circuits

Occidental College	L A Fathe	Interdisciplinary	$105,292	24	9455564
Los Angeles	90041-3384	Department of Physics			

Unified Introductory Calculus and Physics

San Francisco State U	J R Keeffe	Chemistry	$42,758	30	9354596
San Francisco	94132-1722	Department of Chemistry			

Molecular Modeling for the Introductory Organic Chemistry Courses

San Jose City College	M M Bunge	Physics	$157,690	24	9455585
San Jose	95128-2723	Department of Physical Science			

Interactive, Conceptually Based Multimedia Instruction for Introductory Mechanics

San Jose State U	E D Green	Engineering (LLD)	$224,000	24	9551520
San Jose	95106-0760	Department of Electrical Engineering			

Development of an Interdisciplinary Curriculum in Electronic Materials and Devices: Cooking Without Recipes

San Jose State U	T Hsu	Engineering	$250,000	12	9455395
San Jose	95106-0760	Department of Mechanical Engineering			

Undergraduate Curriculum Development on Mechatronic Systems Engineering

San Jose State U	S P Perone	Chemistry	$135,214	36	9455416
San Jose	95106-0760	Department of Chemistry			

Transforming Traditional Quantitative Analysis into a Course in Modern Analytical Science

Santa Clara University	S L Wood	Engineering	$19,575	54	9156103
Santa Clara	95053	Department of Electrical Engineering			

Interactive Tutorial for Engineering Mathematics with Applications in Electrical and Computer Engineering

Sonoma State University	S Schickele	Social Sciences	$168,703	24	9455320
Rohnert Park	94928-3613	Department of Business and Economics			

Networked Financial Simulation Using Lambda MOO Technology

U of Cal Berkeley	C B Moore	Chemistry Initiative	$755,000	12	9455924
Berkeley	94720	Department of Chemistry			

Sweeping Change in Manageable Units: A Modular Approach for Chemistry Curriculum Reform

U of Cal Berkeley	A M Stacy	Chemistry	$190,000	24	9455418
Berkeley	94720	Department of Chemistry			
Biologically-Relevant Chemistry in the Freshman Laboratory					
U of Cal Davis	W H Potter	Physics	$98,796	24	9354528
Davis	95616-8671	Department of Physics			
Reform of the "Non-Calculus" Introductory Physics Course from a Constructivist Perspective					
U of Cal Los Angeles	O L Chapman	Interdisciplinary	$149,999	24	9455570
Los Angeles	90024-1301	Department of Chemistry & Biology			
The UCLA Science Challenge					
U of Cal Los Angeles	S W Strand	Biology	$415,601	36	9455447
Los Angeles	90024-1301	Department of Life Sciences			
Computer-Integrated Introductory Biology Lab					
U of Cal Santa Barbara	M L Carlos	Social Sciences	$200,000	24	9455699
Santa Barbara	93106	Department of Anthropology			
A Multidimensional Computer-Assisted Course for Teaching the Fundamentals of Ethnographic Field Research Methods in a Laboratory Environment to Undergraduates in Anthropology					
U of Cal Santa Barbara	W A Prothero	Geological Sciences	$85,078	24	9455758
Santa Barbara	93106	Department of Geological Sciences			
Multi-Media For a "Hands-On" Oceanography Course					

COLORADO

Bio. Sci. Curric Study	R W Bybee	Biology	$650,000	44	9455725
Colorado Springs	80903	Department of Biological Sciences			
A New Model for Introductory Biology at Two-Year and Community Colleges					
National Technical U	L V Baldwin	Engineering	$117,000	12	9550462
Fort Collins	80521-2807	Office of the President			
1995 National Engineering Faculty Forum: An Interactive Teleconference Series to Share Best Practices in Undergraduate Engineering Education					
U of Colorado Boulder	A J Bedard	Engineering	$95,796	24	9455705
Boulder	80309-0019	Department of Engineering Administration			
Hands-On Engineering Homework: A New Approach to Out-of Class Learning					
U of Colorado Denver	R P Tagg	Physics (LLD)	$94,547	24	9552121
Denver	80217-3364	Department of Physics			
Course Modules in Apparatus Design and Experimental Techniques					
U of Colorado Denver	K Walker	Engineering	$64,210	12	9455422
Denver	80217-3364	College of Engineering & Applied Science			
Engineering, Technology and Culture: With an Emphasis on Race, Gender and the Individual					

CONNECTICUT

Wesleyan University Middletown	J T Rouse 06459	Science and Humanities	$95,000	36	EW-20349

Developing an Undergraduate Major in Humanistic Studies of Science

Yale University New Haven	B B Mandelbrot 06520	Mathematics Department of Mathematics	$203,562	24	9455636

Development of a Course Sequence in Fractal Geometry for Interdisciplinary Undergraduate Education and Increased Mathematics and Science Literacy

DISTRICT OF COLUMBIA

Amer Soc for Eng Ed Washington	F L Huband 20036-1207	Engineering	$49,808	36	9452911

Dissemination of Results From NSF-Supported Engineering Education Projects

Assoc of Amer Geographers Washington	S E Hanson 20036	Social Sciences Department of Geography	$306,144	36	9455632

Developing Active Learning Modules on the Human Dimensions of Global Change

George Washington U Washington	C Martin 20037-2353	Computer Science Dept of Electrical Engineering and Computer Science	$55,000	30	9354626

Integrating Social Impact and Ethics into the Computer Science Curriculum

FLORIDA

Eckerd College St Petersburg	J E Reynolds 33711	Science & Humanities	$122,000	16	EW-20313

Faculty and Curriculum Development in Interdisciplinary Environmental Studies

Rollins College Winter Park	J D Child 32789-4499	Mathematics Department of Mathematics and Computer Science	$25,000	12	9456000

A Planning Seminar for Faculty Participating in the Rollins College Quantitative Learning and Teaching Program

University of Florida Gainesville	B F Carroll 32611	Engineering Department of Aero. Eng, Mech, & Engineering Science	$120,000	24	9455346

Aerospace Concepts for Elementary Education Majors

University of South Florida Tampa	H R Mushinsky 33620-9951	Interdisciplinary Department of Biology	$100,000	24	9455413

Fundamentals of Natural Science for Non-Science Students: An Integrated Approach

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GEORGIA

Emory University	K S Hagen	Chemistry	$134,989	36	9455567
Atlanta	30322	Department of Chemistry			

The Inorganic Illustrator: A 3-D Graphical Supplement for Inorganic and Bioinorganic Chemistry Courses Distributed on CD-ROM

Georgia Tech	E W Thomas	Physics	$80,600	12	9455470
Atlanta	30332	School of Physics			

Precision Teaching of an Introductory Physics Electricity & Magnetism Course for Engineers

Georgia Tech	C Thompson	Engineering	$599,603	36	9453883
Atlanta	30332	GTRI/EOEML			

Multimedia in Manufacturing Education

University of Georgia	J M Affolter	Interdisciplinary (LLD)	$300,000	24	9552283
Athens	30602	State Botanical Garden			

Building Environmental Literacy Through Participation in GIS and Multimedia Assisted Field Research

IDAHO

University of Idaho	M E Gunter	Interdisciplinary	$124,797	42	9254158
Moscow	83843	Department of Chemistry			

Integrated Science for Elementary Teachers: A Course and Practicum Approach to Restructuring Undergraduate Science Preparation for Teachers

ILLINOIS

College of Du Page	P L Sirvatka	Astronomy	$305,000	36	9551536
Glen Ellyn	60137	Department of Natural Science			

Creating Effective Meteorology Laboratory Modules to Improve Curriculum and Enhance Student Transition into Upper Division Coursework

DePaul University	G B Kharas	Chemistry	$70,000	36	9455681
Chicago	60604-2218	Department of Chemistry			

A New Investigative Laboratory for Organic Chemistry Involving Polymer Synthesis and Characterization

Illinois Wesleyan U	T R Rettich	Chemistry	$140,000	36	9455718
Bloomington	61701	Department of Chemistry			

Chemistry Curriculum Innovations

Northern Illinois U	M Krishnamurthi	Engineering	$124,286	24	9455748
De Kalb	60115	Department of Industrial Engineering			

An Innovative Course on Elements of Manufacturing Systems for Non-Engineering Students

Northwestern University	D Meyer	Astronomy	$87,287	24	9354525
Evanston	60208-0001	Department of Physics & Astronomy			

Active Learning Environment for Large Non-Science Majors Astronomy Classes

U of Ill Urbana-Champaign | R E Stake | Mathematics | $6,900 | 6 | 9455577
Urbana | 61801 | Center for Inst. Res. & Curriculum Evaluation
Teacher Preparation Archives Second Printing

INDIANA

Indiana U Bloomington | R R Hake | Physics | $119,692 | 66 | 9253965
Bloomington | 47402-1847 | Department of Physics
Project SOCRATES: Improving Introductory Physics Education Through Interactive Engagement

Purdue University | D D Budny | Engineering | $12,000 | 12 | 9552585
West Lafayette | 47907 | Department of Freshman Engineering
Publishing Conference Proceedings on Mosaic

Purdue University | E L Dubinsky | Mathematics | $104,920 | 24 | 9450750
West Lafayette | 47907 | Department of Mathematics
Calculus, Concepts, Computers and Cooperative Learning: Assessment and Evaluation in Terms of Dissemination Goals

Purdue University | D P Maloney | Physics | $69,678 | 28 | 9455613
West Lafayette | 47907 | Department of Physics
Physical Science: Reasoning and Conceptual Patterns

Rose-Hulman Inst of Tech | M J Moloney | Physics | $100,564 | 12 | 9455442
Terre Haute | 47803 | Department of Physics & Applied Optics
Physics Resources Packets as a Pathway to Tomorrow's Education

IOWA

Clarke College | M L Caffery | Chemistry | $27,755 | 30 | 9354515
Dubuque | 52001-3117 | Department of Chemistry
The Integration of Molecular Modeling Across the Chemistry Curriculum as a Tool for Understanding Chemical Structure and for Developing Critical Thinking Skills

Grinnell College | E A Herman | Mathematics | $199,914 | 24 | 9455618
Grinnell | 50112-0805 | Department of Mathematics and Computer Science
A Modular Interactive Text for Linear Algebra

Iowa State University | T J Greenbowe | Chemistry | $260,621 | 36 | 9455646
Ames | 50011 | Department of Chemistry
Introduction of Modern Instrumentation in the First Two Years of Chemistry: The Iowa Chemistry Curriculum Network (IACCN)

University of Iowa | R L Mutel | Astronomy | $81,660 | 24 | 9455621
Iowa City | 52242 | Department of Physics and Astronomy
Imaging the Universe: A New Curriculum for Undergraduate Astronomy Laboratories

University of Northern Iowa | J P East | Computer Science | $69,812 | 12 | 9455736
Cedar Falls | 50613-4800 | Department of Computer Science
Pattern-Based Programming Instruction

KENTUCKY

Appalachian College Assoc	A W Brown	Computer Science	$19,166	7	9554456
Berea	40403				
Technology in Teaching and Research: A Look at Private Education in Appalachia					
University of Kentucky	R C Edwards	Science & Humanities	$143,000	24	EW-20320
Lexington	40506-0027	College of Arts and Sciences			
The Modern Studies Curriculum: Science, Culture, Society					
University of Louisville	K M Walsh	Engineering (LLD)	$217,273	36	9551869
Louisville	40292	Department of Electrical Engineering			
An Advanced Undergraduate Laboratory for Microfabrication					

LOUISIANA

University of SW Louisiana	M C Mulder	Computer Science	$161,850	12	9455450
Lafayette	70503-2701	Center for Advance Computer Studies			
Educating the Next Generation of Information Specialists, in Collaboration with Industry					

MASSACHUSETTS

Bentley College	C R Hadlock	Interdisciplinary	$100,000	36	9455719
Waltham	02154-4705	Department of Mathematical Sciences			
Modeling Applications in Environmental Management: Preparation of Text and Teaching Guide					
Boston University	E A Godrick	Biology	$162,000	36	9455288
Boston	02118-2394	Department of Biology			
Career Direction through Integrated Introductory Biology-Chemistry Laboratory and Research					
Consort Math/its Applications	W Meyer	Mathematics	$157,956	30	9354509
Arlington	02174-4131	Department of Mathematics & Computer Sci.			
Principles and Practice of Mathematics (Math 101-102)					
Education Development Center	W Harvey	Mathematics	$273,177	24	9450731
Newton	02160	Department of Learning, Teaching and Tech.			
Gateways to Advanced Mathematical Thinking: Linear Algebra and Precalculus					
Five Colleges Inc.	S E Strom	Astronomy	$158,260	24	9455293
Amherst	01002-2324	Department of Physics & Astronomy			
An Interactive Introductory Astronomy Course					
Five Colleges Inc.	D Van Blerkom	Astronomy	$27,337	18	9455529
Amherst	01002-2324	Department of Physics & Astronomy			
A Hypertext-based Study Guide for Introductory Astronomy: Defusing Misconceptions					
Hampshire College	C V D'Avanzo	Interdisciplinary	$26,998	24	9552886
Amherst	01002	Natural Sciences			
Student-active Science: Models of Innovation in College Science Teaching					

Harvard University	D Hughes-Hallett	Mathematics	$381,112	30	9352905
Cambridge	02138-3826	Department of Mathematics			
Bridge Calculus Consortium Based at Harvard					
Harvard University	E Mazur	Physics	$43,500	42	9254027
Cambridge	02138-3826	Department of Physics			
Peer Instruction: Stimulating Renewed Interest in Physics and Other Science and Engineering Courses					
MIT	R P Binzel	Astronomy	$109,270	24	9455329
Cambridge	02139-4307	Earth, Atmospheric and Planetary Science			
Planetary Exploration in the Classroom					
MIT	T F Weiss	Biology	$150,000	36	9455337
Cambridge	02139-4307	Department of Electrical Engineering			
Development of Educational Software for Cellular Biophysics					
Mount Holyoke College	G Davidoff	Science & Humanities	$169,000	34	EW-20327
South Hadley	01075	Department of Mathematics			
Mathematics Across the Curriculum					
Mount Holyoke College	S R Dunn	Interdisciplinary	$150,000	24	9455682
South Hadley	01075	Department of Geology			
The Unity of Science: A Year-Long, Exploration-Oriented Interdisciplinary Science Course					
U of Massachusetts Amherst	C D Condit	Geological Sciences	$70,000	24	9455563
Amherst	01003	Department of Geology and Geography			
Development of a SuperCard Interface for Dynamic Digital Maps in Geology Instruction					
U of Massachusetts Amherst	W J Gerace	Astronomy	$402,860	24	9453881
Amherst	01003	Physics and Astronomy			
TTECCS: Transforming Technical Education with a Classroom Communication System					
U of Massachusetts Amherst	S Das Sarma	Biology (LLD)	$273,459	36	9551531
Amherst	01003	Department of Microbiology			
Intelligent Tutor for Concepts in Molecular Genetics					

MICHIGAN

Calvin College	E D Fife	Mathematics	$100,000	36	9550943
Grand Rapids	49546	Department of Mathematics			
The Mathematics Archives Outreach Program: A Program of Dissemination and Education about Mathematics on the Internet					
Hope College	J Andersen	Mathematics	$54,871	30	9354741
Holland	49423	Department of Mathematics			
Progressive Precalculus Problem Sets for High School and College					
Oakland University	J W Russell	Chemistry	$91,593	12	9455747
Rochester	48309-4401	Department of Chemistry			
Building Conceptual Frameworks with Synchronized Multiple Visualizations					

University of Michigan	A Uribe-Ahumada	Mathematics (LLD)	$100,000	24	9455672
Ann Arbor	48109-1274	Department of Mathematics			
Computer Supported Cooperative Learning Environment for Multivariable Calculus					
University of Michigan	N K Kerner	Chemistry	$135,000	24	9455695
Ann Arbor	48109-1274	Department of Chemistry			
Development of Collaborative, Computer-Networked Laboratories in General Chemistry					
University of Michigan	D J Lewis	Mathematics Initiative	$29,746	24	9456125
Ann Arbor	48109-1274	Department of Mathematics			
Mathematical Sciences and their Applications Throughout the Curriculum					

MINNESOTA

College of St Catherine	M Blackburn	Chemistry	$60,012	36	9455394
St. Paul	55105-1750	Department of Chemistry			
Improving Student Instrumentation Skills with Pre- and Post-lab Computer Simulations					

MISSOURI

U of Missouri Saint Louis	S K Feigenbaum	Social Sciences	$19,466	42	9254299
St. Louis	63121-4401	Department of Economics			
Introductory Microeconomics: The Way We Live					
Washington University	M E Wysession	Geological Sciences	$138,133	36	9455417
St. Louis	63130	Department of Earth & Planetary Sciences			
Educational Earthquake Visualization					

MONTANA

Montana State University	J R Amend	Chemistry Initiative	$49,248	12	9455826
Bozeman	59717	Department of Chemistry			
Planning Grant for Development of Systemic Undergraduate Chemistry Curriculum					
Montana State University	R J Ross	Computer Science	$93,344	12	9455588
Bozeman	59717	Department of Computer Science			
An Interactive Laboratory Infrastructure for Computer Science					

NEBRASKA

U of Nebraska Lincoln	J P Markwell	Biology (LLD)	$48,208	36	9550791
Lincoln	68588-0430	Department of Biochemistry			
Laboratory Exercises in Plant Biochemistry					

NEW HAMPSHIRE

Dartmouth College	R D Masters	Science & Humanities	$207,200	16	EW-20310
Hanover	03755	Department of Government			
Human Nature: Integrating Nature and Nurture					
Dartmouth College	J L Snell	Mathematics	$109,945	30	9354592
Hanover	03755	Department of Mathematics			
Change: Current Studies of Current Chance Issues, Phase II					
Dartmouth College	D W Wallace	Mathematics Initiative	$1,300,000	24	9552462
Hanover	03755	Department of Mathematics			
Mathematics Across the Curriculum					

NEW JERSEY

NJIT	F A Dolan	Engineering	$169,585	12	9455764
Newark	07102-1824	Department of Rehabilitation Engineering			
Curriculum Development - Manufacturing Systems					
R Stockton College of NJ	W J Cromartie	Social Sciences	$100,000	24	9455331
Pomona	08240	Department of Natural Sciences			
Integrating Geographic Information Systems Into Undergraduate Environmental Science Curriculum					
Rutgers U New Brunswick	V Santarelli	Physics	$447,189	36	9455282
New Brunswick	08903	Department of Physics			
Innovative Introductory Physics Laboratory Course					

NEW MEXICO

New Mexico State U	R C Laubenbacher	Mathematics	$21,570	30	9354330
Las Cruces	88003-3699	Department of Mathematical Sciences			
Teaching with Original Sources in Mathematics					
New Mexico State U	B J McNamara	Astronomy	$47,884	42	9253979
Las Cruces	88003-3699	Department of Astronomy			
Astronomy and Writing: An Innovative Approach to Science Instruction					

NEW YORK

Columbia University	E Galanter	Social Sciences	$150,000	12	9455379
New York	10027	Department of Psychology			
The Quantitative and Experimental Study of Human Nature					
Columbia University	J D Hays	Interdisciplinary	$150,000	24	9455688
New York	10027	Lamont-Doherty Earth Observatory			
A New Approach to Earth and Environmental Science Undergraduate Instruction					

Cornell University	P A Karplus	Biology	$100,000	36	9455324
Ithaca	14853-2801	Depart of Biochemistry, Molecular & Cell Biology			
Computer Graphics in Introductory Biochemistry					
Cornell University	J Meinwald	Chemistry	$75,000	24	9354452
Ithaca	14853-2801	Department of Chemistry			
The Language of Chemistry: Introductory Chemistry Based on the Study of Problems at the Interface Between Chemistry and Biology					
CUNY Borough Manhattan Community College	P R Wilkinson	Interdisciplinary	$294,797	36	9455559
New York	10007-1079	Department of Mathematics			
Portfolios to Integrate Mathematics, Science and Computer Science					
CUNY Borough Manhattan Community College	J Lang	Science & Humanities	$120,000	24	EW-20307
New York	10007	Social Science Department			
BMCC Project in Science, Technology and Society					
CUNY Brooklyn College	M I Sobel	Interdisciplinary	$226,589	36	9455430
New York	11210	Department of Physics			
Taking Ownership: Science as Constructive Inquiry (SCI) - An Interdisciplinary, Urban, Multicultural Curriculum Development Program					
CUNY City College	D K Gosser	Chemistry Initiative	$425,000	12	9455920
New York	10031	Department of Chemistry			
A Workshop Chemistry Curriculum					
CUNY Queens College	J Waxman	Computer Science	$85,835	12	9455635
Flushing	11367-1575	Department of Computer Science			
A Second Course in Computing for Non-Majors					
Rensselaer Polytechnic Inst	W E Boyce	Mathematics Initiative	$1,210,000	24	9552465
Troy	12108-3522	Department of Mathematical Sciences			
Mathematics and Its Applications in Engineering and Science: Building the Links					
SUNY Buffalo	D S Hodge	Geological Sciences	$75,000	24	9455300
Buffalo	14260	Department of Geology			
New Geology Laboratories: Interactive Data Acquisition, Analysis, and Multimedia Modules of Geologic Phenomena, Part II					
SUNY Dutchess Comm. Coll.	J Tavel	Interdisciplinary	$25,145	36	9254184
Poughkeepsie	12601	Math, Physical & Computer Sciences			
Basics for Technicians: An Integrated Course of Study Encompassing Mathematics, Chemistry, and Physics					
SUNY Oswego	P A Shuart	Mathematics	$184,393	24	9455638
Oswego	13126	Office of Learning Support Services			
State University of New York (SUNY) Pre-Precalculus Program: Empowering Underprepared Two- and Four-Year College Mathematics Students					
SUNY Stony Brook	R K Larson	Interdisciplinary	$15,025	6	9150417
Stony Brook	11794-0001	Department of Linguistics			
Linguistic Semantics as Science					

NORTH CAROLINA

Duke University	A W Biermann	Computer Science	$100,000	12	9455507
Durham	27703-2570	Department of Computer Science			

"This-Is-How-A-Computer-Works": A Software System for Lecture Demonstrations, Laboratory Exercises, and Home Study

North Carolina State U	D F Ollis	Engineering (LLD)	$200,000	24	9550927
Raleigh	27650-5067	Department of Chemical Engineering			

Freshman Laboratory for Product and Process Engineering

Sigma XI Science Research Soc	R D Bereman	Interdisciplinary	$153,411	30	9354599
Research Triangle Park	27709	Sigma Xi			

Visualization Technologies in Environmental Curricula (VTEC)

UNC Chapel Hill	J E White	Mathematics (LLD)	$249,998	24	9551273
Chapel Hill	27514	Department of Education			

Library for Interactive Studies in Mathematics

NORTH DAKOTA

University of North Dakota	T C Owens	Engineering	$319,940	36	9455466
Grand Forks	58202	School of Engineering and Mines			

Enhanced Curriculum for Undergraduate Engineering Adult Learners in Industry

OHIO

Ohio State University	G Rizzoni	Interdisciplinary	$10,000	24	9354403
Columbus	43210-1016	Department of Mechanical Engineering			

Design of Electro-Mechanical (Mechatronic) Systems - An Integrated Inter-Departmental Curriculum

OKLAHOMA

Oklahoma State University	B D Evans	Mathematics	$204,386	40	9455305
Stillwater	74078	Department of Mathematics			

Mathematics Without Calculus

University of Oklahoma	S R Ryan	Physics	$34,215	24	9455740
Norman	73069-8813	Department of Physics and Astronomy			

Production of Short, Animated Audio/Visual Instructional Aids for Physics Which Illustrate the Application of Physics to Technology

OREGON

Oregon State University	D Lawrence	Interdisciplinary	$100,000	24	9455665
Corvallis	97331-5503	Department of Geosciences			
Multimedia Computer-Assisted Instruction in the Geosciences for Undergraduate Education					
Portland State University	W G Becker	Interdisciplinary	$121,511	24	9455726
Portland	97207-0751	Department of Science Education			
Pacific Northwest Environmental Studies Program: A Collaborative Interdisciplinary Curriculum Development Project					
Portland State University	M J Flower	Science & Humanities	$176,000	24	EW-20331
Portland	97207	Interdisciplinary Science Studies			
A General University Science-Humanities Curriculum					
University of Portland	M M Wilson	Biology	$51,293	15	9455601
Portland	97203-5743	Department of Biology			
Coupling Mathematics and Life Science Courses					

PENNSYLVANIA

Bucknell University	J J Mead	Computer Science	$58,283	19	9455489
Lewisburg	17837	Department of Computer Science			
An Assertion-Based Programming Methodology for Introductory Programming Courses					
Carnegie Mellon University	C I Davidson	Engineering	$188,860	24	9455399
Pittsburgh	15213-3815	Department of Civil & Environmental Engineering			
Enhancing the Environmental Content of Undergraduate Engineering Curricula					
Dickinson College	P W Laws	Physics	$725,000	36	9455561
Carlisle	17013	Department of Physics & Astronomy			
Activity Based Physics: Curricula, Computer Tools, and Apparatus for Introductory Physics Courses					
Dickinson College	K L Laws	Physics	$52,248	24	9455656
Carlisle	17013	Department of Physics and Astronomy			
Project-Centered Physics Curriculum					
Drexel University	S J Hartley	Computer Science	$19,428	12	9455307
Philadelphia	19104	Department of Mathematics & Computer Science			
A Hypermedia Lab Manual for Operating Systems					
Drexel University	W E Magee	Biology	$48,794	6	9253994
Philadelphia	19104	Department of Bioscience & Biotechnology			
An Enhanced Bioscience Education Program for the Introductory Years of the Biology Major and for Interested Preteachers					
Franklin & Marshall College	P A Leber	Chemistry	$25,596	12	9455693
Lancaster	17604-3003	Department of Chemistry			
Theme-Based Bidisciplinary Chemistry Laboratory Modules					

Gettysburg College	L A Marschall	Astronomy	$177,120	30	9354514
Gettysburg	17325	Department of Physics			
Project CLEA: Contemporary Laboratory Experiences in Astronomy					
Haverford College	L M Butler	Mathematics	$25,000	18	9455972
Haverford	19041	Department of Mathematics			
Mathematics Concentrations in Economics and Chemistry					
Lehigh University	K J Schray	Chemistry Initiative	$50,000	12	9455822
Bethlehem	18015-3005	Department of Chemistry			
Chem PRIME: A Curriculum of Chemical Principles Through Integrated Multiple Exemplars					
PA State U University Park	R Roy	Engineering	$45,000	24	9354440
University Park	16802-1503	Intercollege Materials Research Lab			
Development of Materials Synthesis Courses and Their Innovative National Dissemination					
University of Pennsylvania	D M De Turck	Mathematics Initiative	$1,197,387	24	9552464
Philadelphia	19104	Department of Mathematics			
Middle Atlantic Consortium for Mathematics and Its Applications Across the Curriculum					
University of Pennsylvania	C J McMahon	Engineering	$100,000	12	9455333
Philadelphia	19104	Department of Materials Science			
Development of a CD-ROM Based Multimedia Teaching Package for Introductory Materials Science and Engineering					

RHODE ISLAND

Brown University	E Bakewell	Social Sciences	$123,680	12	9455587
Providence	02912	Department of Anthropology			
Project on the Language-Art Interface: Vision and Voice - Rethinking Human Communication					

SOUTH CAROLINA

Clemson University	M M Cooper	Chemistry	$159,948	36	9455526
Clemson	29634-5702	Department of Chemistry			
Cooperative Organic Laboratories					
U of SC Columbia	J D Spurrier	Mathematics	$29,960	24	9455292
Columbia	29208	Department of Statistics			
A Capstone Course in Statistics					

TENNESSEE

Amer Math Assoc Two Year Colleges	M E Mays	Mathematics	$34,320	36	9255850
Memphis	38134	Department of Mathematics and Computer Science			
Curriculum and Pedagogy Reform at Two-Year Colleges: Moving Beyond Myths to Standards					

TEXAS

Amarillo College	K C Wetzel	Mathematics	$75,394	24	9455606
Amarillo	79178-0001	Department of Mathematics			

Mathematical Interactive Network Design (MIND): A Computer Lab for Developmental Mathematics

Baylor University	B A Pierce	Interdisciplinary	$101,620	24	9455440
Waco	76798-7088	Department of Biology			

Development of an Integrated, Multidisciplinary Science Literacy Course for Comprehensive Universities

Central Texas College	P J Ray	Interdisciplinary	$132,905	24	9455599
Killeen	76540-9990	Department of Science			

Discovery - Based CAI Fundamentals of Science Course Focused on Relationship Thinking, History of Science, and Math Applications

Southwest Texas State U	M Busby	Science & Humanities	$153,698	12	EW-20339
San Marcos	78666				

Integrating Curricula Through Southwestern Studies: A Faculty Institute

Southwestern University	D A Naumann	Computer Science	$23,698	18	9455660
Georgetown	78626	Department of Mathematics and Computer Science			

Program Derivation for a Data Structures Course

Texas Tech University	D J Bagert	Computer Science	$56,999	12	9455614
Lubbock	79409-4609	Department of Computer Science			

Using Iconic Environments to Teach Procedural and Object-Oriented Programming Concepts

University of Texas Austin	J Kappelman	Social Sciences	$73,720	24	9354427
Austin	78712-9998	Department of Anthropology			

A Laboratory Curriculum for Physical Anthropology on CD ROM

University of Texas Austin	P S Schmidt	Engineering	$10,000	42	9254005
Austin	78712-9998	Department of Mechanical Engineering			

Video Resources for Instruction in Introductory Engineering Thermodynamics

UTAH

University of Utah	J L Zachary	Computer Science	$87,125	12	9455478
Salt Lake City	84112-1201	Department of Computer Science			

Computer-based Laboratories for Introductory Computing Courses for Science and Engineering Majors

VIRGINIA

Radford University	P A Sandberg	Geological Sciences	$247,110	36	9455542
Radford	24142	Department of Arts & Sciences			

Computer-Aided Learning Modules for General-Education Geology Courses

University of Virginia | W A Wulf | Computer Science | $64,548 | 12 | 9156112
Charlottesville | 22906-9003 | Department of Computer Science
Development of a Set of "Closed Laboratories" for an Undergraduate Computer Science Curriculum

VA Polytechnic Inst & State U | P N Palettas | Mathematics | $57,866 | 12 | 9455578
Blacksburg | 24061 | Department of Statistics
Revitalizing Introductory Statistics for Engineering by Capitalizing on Interdisciplinary Cooperation and State-of-the-Art Technology

VA Polytechnic Inst & State U | C A Shaffer | Computer Science | $19,768 | 12 | 9455403
Blacksburg | 24061 | Department of Computer Science
The GeoSim Interface Library for Introductory Programming Courses

VA Polytechnic Inst & State U | B M Tissue | Chemistry | $80,000 | 24 | 9455382
Blacksburg | 24061 | Department of Chemistry
Development and Evaluation of Internet-Based Hypermedia Chemistry Tutorials

WASHINGTON

N Seattle Community College | E Hamilton | Engineering | $75,000 | 24 | 9455566
Seattle | 98103-3514 | Department of Engineering
Course and Curriculum Development: Integrating Pre-Engineering Curriculum

Seattle Community College S | T O Murray | Engineering | $429,680 | 12 | 9453739
Seattle | 98106-1401 | Dean of Technical Education
Washington State Manufacturing Technology Standards, Competencies and Curriculum Development

University of Puget Sound | D C Magnus | Science & Humanities | $143,500 | 12 | EW-20332
Tacoma | 98416 | Department of Philosophy
Scientific, Ethical and Social Challenges of Contemporary Genetic Technology

University of Washington | B Grunbaum | Mathematics | $30,000 | 12 | 9300657
Seattle | 98195 | Department of Mathematics
Mathematical Sciences: Geometry of Configurations, Polygons and Polyhedra

University of Washington | L C McDermott | Physics | $754,830 | 36 | 9354501
Seattle | 98195 | Dept. of Physics
A New Model for Physics Education in Physics Departments: Improving the Teaching of Physics from Elementary through Graduate School

University of Washington | R O Watts | Chemistry Initiative | $49,929 | 12 | 9455830
Seattle | 98195 | Department of Chemistry
Curriculum for Chemistry in a Large Urban University

WEST VIRGINIA

Marshall University | D K Walker | Computer Science | $59,121 | 18 | 9455314
Huntington | 25701-1522 | Department. of Computer Science & Software Devel.
Development of Lecture Room Demonstration Experiments to Improve the Computer Literacy Course

WISCONSIN

Beloit College	J R Jungck	Biology	$161,719	30	9354813
Beloit	53511	Department of Biology			
The BioQUEST Curriculum and Learning Tools Development Project					
Beloit College	B Spencer	Chemistry Initiative	$705,000	12	9455918
Beloit	53511	Department of Chemistry			
ChemLinks Coalition: Making Chemical Connections					
Lawrence University	E Hoft-March	Science & Humanities	$160,000	44	EW-20321
Appleton	54912	Anthropology and French			
The Gender Studies Core-Course Sequence: Examining and Integrating Disciplinary Perspectives					
U of Wisconsin Madison	A B Ellis	Chemistry	$50,000	42	9254107
Madison	53706-1490	Department of Chemistry			
Development of a Materials-Oriented General Chemistry Course					
U of Wisconsin Madison	J E Handelsman	Biology	$19,670	42	9156087
Madison	53706-1490	Plant Pathology			
Biological Literacy Through Classroom Community					
U of Wisconsin Madison	J W Moore	Chemistry Initiative	$949,968	12	9455928
Madison	53706-1490	Department of Chemistry			
Establishing New Traditions: Revitalizing the Curriculum					
U of Wisconsin Madison	P H Williams	Biology	$31,236	12	9455616
Madison	53706-1490	Department of Plant Pathology			
Conferences on Communicating and Assessing Innovative Strategies for Life Sciences Teaching to Undergraduates					
U of Wisconsin River Falls	M S Bergland	Biology	$108,464	36	9455425
River Falls	54022-5013	Department of Biology			
Interactive Multimedia Simulations of Experimental Biotechnology Laboratories for Introductory Biology Students					

INDEX OF PROJECT DIRECTORS

A

Abbitt, John D. 40
Affolter, James M. 59
Allen, Emily L. 41
Amend, John R. 105
Andersen, Janet 71
Anderson, Mark R. 14
Anderson, Steven 42
Arena, Susan L. 105
Arny, Thomas T. 93
Awbrey, Susan M. 12

B

Bagert, Donald J. 32
Bakewell, Elizabeth 98
Baldwin, Lionel V. 45
Bales, Roger C. 64
Ball, Richard J. 74
Barnette, N. D. 31
Barry, Susan R. 55
Beck, Walter E. 27
Becker, David 12
Becker, William G. 66
Bedard, Alfred J. 48
Beeman, William O. 98
Bereman, Robert D. 56
Berger, Carl F. 17
Bergland, Mark S. 8
Bergman, Robert G. 103
Biermann, Alan W. 24
Binzel, Richard P. 93
Birnie, Richard W. 107
Bitterwolf, Thomas E. 58
Bjedov, Goranka 41
Blackburn, Marlana 16
Bogart, Kenneth P. 107
Boyce, William E. 108
Boyle, Robert J. 80
Bramblett, Claud A. 95
Bridges, Charles W. 89
Briggs, Stephen R. 75
Brown, Alice W. 33
Budny, Daniel D. 41
Bulman, Teresa 66
Bunge, Mark M. 83
Burnham, Christopher C. 89
Bursik, Marcus I. 52
Busby, Mark 111
Butler, Laurie J. 74
Butler, Lynne M. 74
Bybee, Rodger W. 2

C

Caffery, Mary L. 17
Calloni, Ben A. 32
Campbell, Charles T. 105
Carlos, Manuel L. 96
Carranza, Ruth 48
Carroll, Bruce F. 40
Chahryar, Hamid 31
Chapman, Orville L. 61
Child, James D. 75
Cohen, Mary A. 59
Coleman, Lawrence B. 84
Condit, Christopher D. 52
Cooney, Patrick J. 85
Cooper, Melanie M. 15
Cooper, P. Richard 92
Crauder, Bruce C. 68
Crawford-Brown, Douglas J. 56
Cresap, David M. 6
Cromartie, William J. 95
Cronin-Jones, Linda 40
Cuoco, Albert A. 77

D

D'Avanzo, Charlene V. 61
Das Sarma, Shiladitya 8
Davidoff, Giuliana 116
Davidson, Cliff I. 38
De Toma, Frank J. 55
Demuth, Katherine 98
Denman, Richard T. 26
Dennis, Tom R. 55
Dershimer, Charles 17
Desharnais, Robert A. 63
Dessouky, Mohamed I. 49
DeTurck, Dennis M. 107
Dolan, Frank A. 46
Doran, Michael V. 27
Drake, Janet M. 27
Dubinsky, Edward L. 76, 77
Dufresne, Robert 91
Dunn, Steven R. 55

E

East, J.P. 27
Edwards, Richard C. 113
Edwards, Suzan 93
Eison, James A. 62
Ellis, Arthur B. 11
Englert, Peter A. 16
Evans, Benny D. 68
Ewen, Dale 71
Eyres, Davene 42
Ezekoye, Ofodike A. 35

F

Fathe, Laurie A. 63
Feigenbaum, Susan K. 99
Feinstein, David L. 27
Ferrini-Mundy, Joan 77
Fife, Earl D. 67
Fisher, Sue 117
Flower, Michael J. 118

G

Galanter, Eugene 98
Gammon, Steven D. 58
Garfunkel, Solomon A. 68
Geissinger, Ladnor D. 75
Gerace, William J. 91
Gladney, Larry. 107
Gleason, Andrew M. 76
Godrick, Elizabeth A. 5
Golding, Jonathan 113
Gonzalez, Elma 1
Gosser, David K. 101
Graumlich, Lisa J. 64
Green, Evan D. 41
Green, Mary Jean 107
Greenblatt, Martha 11
Greenbowe, Thomas J. 12
Greenstein, George S. 93
Gronert, Scott 14
Grunbaum, Branko 73
Grutzeck, Michael W. 36
Gunter, Mickey E. 58

H

Hadlock, Charles R. 62
Hagen, Karl S. 21
Hake, Richard R. 79
Hamilton, Earl 42
Handelsman, Jo E. 7
Hanley, Thomas R. 43
Hanson, Susan E. 97
Hart, Stephen 113
Hartley, Stephen J. 29
Harvey, Wayne 77
Hausman, Robert E. 5
Hayden, Michael B. 92
Hays, James D. 56
Heath, John E. 105
Hemwall, Martha 114
Herlth, Clifford 83
Herman, Eugene A. 67
Hirschboeck, Katherine K. 64
Hodge, Dennis S. 52
Hoft-March, Eilene 114
Holler, Jim 113
Howell, John R. 35
Hsu, Tai-Ran 38
Huband, Frank L. 42
Hubele, Norma F. 39
Hudgings, James G. 46
Hughes-Hallett, Deborah 76
Husch, Lawrence S. 67

I

Ibarra, Rufino 83
Ibrahim, Nabil 38
Ireland, Thomas R. 99

J

Jablon, Paul 65
Jain, Pankaj 85
Johnson, Lynn E. 37
Johnson, Margaret A. 2
Johnston, William 117
Jungck, John R. 1

K

Kantowski, Ronald 85
Kappelman, John W. 95
Karplus, Paul A. 7
Kearney, Robert J. 58
Keeffe, James R. 14
Keeley, Robert J. 71
Keene, Carol 37
Kegley, Susan E. 13, 103
Kerner, Nancy K. 17
Keyhani, Ali 35
Kharas, Gregory B. 20
Kincaid, William B. 2
King, Donald M. 105
Kleinstein, Arlene 70
Klier, Kamil 106
Klyczek, Karen K. 8
Koch, Roy W. 66
Kodadek, Christopher R. 6
Kosky, Charles 59
Kowalski, Bruce R. 105
Kozma, Robert B. 12
Kramer, Randall A. 56
Kreider, Donald L. 107
Krishnamurthi, Murali 49
Kuhn, Harold W. 74

L

Lang, Jonathan 114
Langan, David D. 27
Larson, Richard K. 55
Laubenbacher, Reinhard C. 68
Laursen, Sandra L. 102
Lawrence, Robert D. 65
Laws, Kenneth L. 80
Laws, Priscilla W. 85
Leake, Woodrow W. 42
Leavitt, Steven W. 64
Leber, Phyllis A. 19
Lederman, Norman G. 65
Lee, Lawrence A. 56
Lemke, David 111
Leonard, William J. 91
Levin, Sharon G. 99
Lewis, Nathan S. 11
Lidtke, Doris K. 25
Lisensky, George C. 11
Lo, Chor-Pang 59
Longenecker, Herbert E. 27
Luehrmann, Mia K. 92
Luetzelschwab, John W. 80
Lum, Lewis 6
Lundeberg, Mary A. 8

M

Magee, Wayne E. 3
Magnus, David C. 112
Malone, Diana F. 17
Malone, Thomas F. 56
Maloney, David P. 81
Mandelbrot, Benoit B. 69
Markwell, John P. 3
Marschall, Laurence A. 92
Marshak, Stephen 54
Martin, C. Dianne 24
Martin, Presley F. 3
Masters, Roger D. 112
Mays, Marilyn E. 71
Mazur, Eric 79
McCabe, George P. 76
McCafferty, Geoffrey 98
McDermott, Lillian C. 83
McMahon, Jr., Charles J. 43
McNamara, Bernard J. 89
McNeal, Ann P. 61
Mead, Jerud J. 30
Meinwald, Jerrold 15
Mestre, Jose P. 91
Meyer, David 89
Meyer, David G. 48
Meyer, Walter 68
Micikas, Lynda B. 2
Mili, Lamine 77
Moloney, Michael J. 88
Moore, C. Bradley 103
Moore, John W. 101
Moore, Robert T. 67
Morawski, Jill 117
Morris, Robert J. 65
Mukherjee, Pritish 62
Mulder, Michael C. 25
Mumford, David 76
Murnick, Daniel E. 86

Murray, Thomas O. 40
Mushinsky, Henry R. 62
Mutel, Robert L. 90

N

Naumann, David A. 26
Noell, Alan V. 68
Nolan, Mary L. 65
Novak, Gary A. 63

O

Oliver, David J. 58
Ollis, David F. 45
Owens, Thomas C. 36
Oxtoby, David W. 102

P

Pacitti, Patricia A. 70
Palettas, Panickos N. 77
Parker, Gregory A. 85
Parson, William W. 105
Patrick, Alfred J. 70
Pelton, Mary Helen 36
Pengelley, David J. 68
Penner-Hahn, James E. 17
Pepe, Michael D. 67
Perlman, Robert 112
Perone, Sam P. 16
Pesek, Joseph 16
Pfirman, Stephanie L. 56
Pfister, Hans 80
Pierce, Benjamin A. 60
Pitts, William K. 43
Pool, John R. 72
Potter, Wendell H. 84
Poucher, Carol M. 70
Previato, Emma 5
Prothero, William A. 51

Q

Quinn, Jennifer J. 63

R

Rabbani, Syed G. 57
Radel, Stanley 101
Ramm, Dietolf 24
Ray, Paula J. 57
Redish, Edward F. 85
Reeves, Thomas C. 59
Reinhardt, William P. 105
Reitan, Paul H. 52
Rettich, Timothy R. 18
Reynolds, John E. 115
Rizzoni, Giorgio 35
Robinson, William R. 11
Ross, Rockford J. 26
Rouse, Joseph T. 117
Roy, Rustum 36
Rubin, Edward S. 38
Rushing, Ann E. 60
Russell, Arlene A. 61
Russell, Christine M. 12
Russell, Joel W. 12
Ryan, Stewart R. 85

S

Sagik, Bernard P. 3
Samuel, Patricia L. 5
Sandberg, Philip A. 54
Santarelli, Vincent 86
Schickele, Sandra 96
Schmidt, Philip S. 35
Schray, Keith J. 106
Schwartz, Robert 116
Schwingendorf, Keith E. 76
Sequeira, Luis 7
Shaffer, Clifford A. 31
Shapiro, Liza J. 95
Sharp, Karen 71
Shende, Anil M. 30
Sheridan, Michael F. 52
Shuart, Patricia Ann 70
Sirvatka, Paul L. 90
Skrutskie, Michael F. 92
Snell, J. Laurie 69
Snow, Michael D. 6
Snyder, Glenn 92
Sobel, Michael I. 65
Sokoloff, David R. 85

Spencer, Brock 102
Spilker, Robert L. 108
Spurrier, John D. 72
Stacy, Angelica M. 13, 103
Stake, Robert E. 74
Steffek, Daniel J. 17
Stein, Michael L. 74
Stewart, Gay B. 82
Stewart, James H. 1
Stone, Craig 16
Strand, Steven W. 1
Strom, Stephen E. 93
Susskind, Tamar Y. 12
Swanson, Todd 71
Swartz, James E. 102
Szczesniak, M. M. 12

T

Tagg, Randall P. 81
Tang, Michael S. 37
Tavel, Judith 58
Taylor, David 89
Thomas, Edward W. 87
Thomas, Sarah R. 27
Thompson, Chris 47
Thornton, Ronald K. 85
Tissue, Brian M. 14

U

Uribe-Ahumada, Alejandro 73

V

Vacher, Henry L. 62
Van Blerkom, David 92
Vignes, Roy 33
Voss, Richard F. 69

W

Walker, David K. 31
Walker, Kenneth 37
Walker, Neff 87
Wallace, Dorothy W. 107
Wallingford, Vernon E. 27
Walsh, Kevin M. 43
Ward, Sandra N. 55
Warren, David S. 55
Watts, Robert O. 105
Waxman, Jerry 28
Weiner, Michael 101
Weiss, Thomas F. 4
Westmoreland, David 117
Wetzel, Kathryn C. 72
Wheeler, Lawrence P. 118
White, James E. 75
White, Richard H. 93
Whittingham, M. Stanley 11
Wilkinson, Patricia R. 59
Williams, Paul H. 5
Wilson, Marlene M. 6
Winkler, Anne E. 99
Wolf, Neil S. 80
Woo, L. Keith 12
Wood, Sally L. 44
Woolf, Beverly P. 8
Worrell, Jay H. 62
Wulf, William A. 23
Wysession, Michael E. 53

Z

Zachary, Joseph L. 29
Zohdy, Mohammed A. 12
Zumdahl, Steven S. 105

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